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The SCIENCE COUNSELOR

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The Science Counselor

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Selecting Textbooks . . .

There are said to be eighteen different methods of selecting a textbook. All may be good. None is infallible.

One publisher whose textbooks in science are widely used in high schools, believes that formal scorings may well be indulged in for they are now the fashion, but he is frank to state that in his opinion no other method is as good as putting the job in the hands of one competent expert who knows the subject. He quotes a colleague as asking, "Who can score the soul of a book?"

This much is certain. Textbooks are such important tools that they must not be chosen blindly. Sincere efforts must be made to find the text that is best suited to the local situation. The best book cannot be selected without study and deliberation.

It was with this thought in mind that we requested four important teachers in the secondary schools to give to our readers their ideas of the points to be considered in selecting textbooks in their own individual science fields. Their papers follow. They will inform and enlighten. Should our readers later be called upon to suggest, or to approve the adoption of a new text, they will know something of the methods that are now being used.

Here they may have the benefit of the considered thought of teachers who have given careful consideration to the difficult but important task of finding the right book.

Choosing a General Science Textbook

• By Franklin B. Carroll, Ph. D., (*University of Pennsylvania*)
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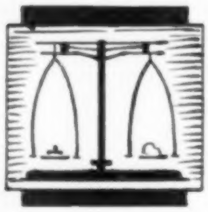

The present offering on evaluation of textbooks is a brief commentary in educational accord with the comforting characterization of science as common sense orderly arranged. It attempts to present some of the common sense of judging a science textbook.

What the teacher wishes of a book, and what forces delimit his situation are matters that deserve attention before proceeding with a selection. Use varies from that of a complete guide of study and teaching practise to that of occasional reference, and circumstances are as various as superior officers. Let us put the matter familiarly.

Should you live in a situation in which you are bound and dragged through a course of study to be vicariously tormented at the end by a standard test administered to your pupils, you need a text in which every jot and tittle of your course of study are listed where they may be memorized. Textbooks on the market conform to courses of study, chiefly to the courses of prominent cities and states with good purchasing power. Bold face headings and short passages of text form a satisfactory catechism.

Should you live in an atmosphere of "scientific method", you will find textbooks and accompanying manuals through which you may conduct your classes with confidence and little forethought. Experiments are plainly laid out so the pupil need not go astray, provided the teacher "checks" regularly. The qualities of a scientist are duly developed, and even listed in a form in which they may be memorized. After the faithful teacher has guided pupils, well-broken to harness, by carefully planned stages to the end of the course, the trained pupils will respond reflexly to appropriate stimuli in the final "test".

Should you enjoy the extreme freedom of progressive education, to follow the lure of fancy into lone lanes that zigzag about the fields of knowledge, skirting the morasses and brambly thickets of difficult questions, you need a library of easy syllables. A limited number of copies each of several texts selected from the market will form a semi-suitable collection. A reference library will supplement the texts.

Should the course be charted along established lines with permitted minor variations to accommodate the personalities of pupils and teachers as well as environment and supplies, the wide market of general science books will allow considerable choice. The "minimum essentials" of core topics will be found to be common to the majority of texts. The minor topics included may be a determining factor in the selection of a text.

After a check of content, a rather careful study of adequacy of treatment of required questions is important. A desire to be of wide service has led some authors and publishers to include so many topics of interest that mere mention of many topics constitutes text treatment. To make an impression upon the pupil, his attention must be held for a measurable period. A subject must be developed with sufficient deliberation to impress the pupil of its worth. Although a vague impression has an importance as background, for study the pupil should have the benefit of a definite question, a definite procedure and a definite conclusion, even though such conclusion may be suspended decision while awaiting clearly defined data. A bewildered pupil suffering under continual bombardment of minor mention of facts may easily become an indifferent pupil, satisfied to have heard of the matter under discussion. Although "relative mastery" may be variously and loosely interpreted, a desire for mastery at least to the extent required by class treatment is well worth developing in the pupil.

Is the text within the grasp of the pupil? The present writer likes to hand a newly-published examination copy to a mediocre pupil with an assignment of a new lesson. A judgment by the teacher on the clarity of a text is sometimes deceptive. A blanking out of one's previous knowledge to attain the position of the pupil is difficult. Didactic treatment in the text may fail by its very directness to hold the attention of the pupil. The pupil must be aided in the wearying struggle of slogans and words versus ideas and thought. Too often a hasty and passive reading of words is mistaken by the pupil for studying, and memorization of phrases substitutes for understanding. Such a comfortable habit is not always changed by the test-conscious teacher hurrying over a crowded course. A function of textbook writing is to arouse the pupil from comfortable passivity, to maintain his interest and to clarify his thought. It must develop suitable language for his use, but it must not leave him thoughtlessly repeating words. No formula for judgment applies. Each treatment must be judged by its effect.

An occasional pupil is lured ahead by a pleasing narrative, a minor victory for the teaching, the subject and the book. A danger, however, attends the turning of a textbook into a story. A casual reading may have a disadvantage in leaving the pupil with a feeling of sufficient familiarity when little of basic importance has been grasped. Skilful reminder of the seriousness of the subject may enter as problems, didactic presenta-

tion or other change of manner. Self-administered tests would have a value if pupils could be induced to use them. A nice balance between the style that pleases and the thought that arouses is sought in a textbook.

Does the text develop sufficiently the basic principles of science? Are the generalizations so introduced that the pupil is led to understand the principle and to grasp its importance in dealing with particular instances? Is the pupil led to apply the principle subsequently? Are the principles used to develop a major theme, a message of science, or are they items in a catalogue? The skilful writer so places the principle within the grasp of the pupil that it will become a familiar intellectual tool. These qualities can not be hastily judged.

The illustrations form an important part of the textbook. Aside from the very desirable consideration of attractiveness, they are a valuable means of teaching. A study of the figures in conjunction with the accompanying text is advisable. The illustrations may substitute for more direct contact with reality, as in field study, or they may serve to re-create a situation in which the pupil has been placed in the laboratory. They may present additional data in more direct form or they may clarify textual discussion. In judging the value of the figure one should call to mind its purpose, its attractiveness, its clarity, and its probable effectiveness in attaining its end. Picture-study technique deserves attention.

"Teaching aids" may serve various purposes. The "device" should be measured against the purpose. If the purpose is to aid the pupil when a lesson is assigned without previous treatment in class, the significance of the study should be adequately developed in the device. The pupil should approach the study with a question clearly in mind, a plan for study, and means for developing and recognizing the answer. If the device is to aid the pupil in testing himself, the questions should be brief, even abrupt, for pupils are usually satisfied if they have "studied the lesson." The test questions should distinguish for the pupil the chief concept from explanatory discussion or illustrative instance. If the teaching device is suggestion or direction for laboratory, field, or library study it should be judged on the basis of the pupil's ability to carry out the work from the directions and profit by it. Teachers of experience will dismiss many suggested "aids" and tests as irrelevant or trivial where serious effort is advisable.

Terms, irreverently dubbed "pedaguese", should not be allowed to place a false value on a book. Terms are used in the literature of school phenomena with an assurance and indefiniteness that might give pause to a teacher of science. Comments on the evaluation of textbooks have assumed that certain terms indicate values of educational practices as established, where a more scientific attitude would leave the matter open to question. "Unit" and "problem" are spoken with arrogant authoritarianism, although "project" is fading a little into a passing style. These terms must be recognized as abstractions of varying meaning in the intellectual activity of the pupil, often merely avenues of satisfaction in his relationship with his teacher. Some texts contain ludicrous attempts to create units, problems and projects. A textbook that measures well in other respects need not be condemned for lack of problems and unit organizations. There are other valid ways of learning.

Much has been said of "pupil viewpoint" and "native interests". Investigators, however, arrive at very different conclusions as to what they are. "Emotional satisfaction" has been offered as the psychological lure to pupil action, but the convenient phrase gives us little guidance. Pupils find satisfaction in the commendation of a favorite teacher that repays the effort spent on "getting a lesson." A terse summary may give the impatient pupil the greatest satisfaction. Judgment of textbooks on the basis of pupil viewpoint, interest and probable satisfaction must be decidedly qualified.

"Experience" also has become a technical term in educational jargon. The experience of the pupil has been so limited that attempts to expand his field have led to the creation of artificial situations that approach burlesque. A frank presentation of a formal experiment related more to the life of the laboratory than to the life in society is to be recognized as preferable to a crude mimicry. Serious study still has a place in the schools. Textbook "experiences" are to be examined with skepticism.

Among the popular educational fallacies is the assumption that "supplementary activities" or the indication of "minimum" and additional passages provides for individual differences. Such differences are emotional as well as intellectual problems and are not to be measured in quantity of text nor by number of activities. Although a differentiation of levels in the text may have a value, the provisions should be examined critically by the teacher who is to use the book.

If one desires a scheme for objective evaluation or relief from the tedium and responsibility of arriving at a judgment, there are score cards in the literature. It is well to evaluate a score card in the light of one's own study and experience. The reluctance of teachers to change a book is often a recognition, more or less consciously, that a book, if reasonably good, is a secondary matter. The abstract measurement of the score card lacks the psychological factor of the teacher. There are still imponderables in education. If after rating a book high on a score card, there is an overwhelming urge to set aside the verdict, the urge is probably right.

For those who wish a more formal study of evaluation of textbooks the following references will serve to open the way to a bibliography.●

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What Physics Text Best Suits Your Course?

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The conscientious choosing of a physics text for secondary school use is a serious and difficult task. In the average school the wise principal assumes only general supervision in the matter of textbook selection and use. He, of course, checks to see that it is appropriate and in harmony with certain legal requirements. However, in view of the special knowledge of physics required, the actual selection should be made by the physics department head in consultation with the department teachers. One must guard against the possibility of choosing a text simply because of familiarity rather than excellence.

Probably very few physics teachers will dispute the fact that most physics teaching is done from texts. Young and inexperienced teachers especially are inclined to slavishly follow the textbook. Therefore, the contents of the physics text used largely determines the content of the course of study. Selecting the text may then become an important factor in the improvement of teaching.

Paving the way for the "recitation-testing" evil should be discouraged. While physics textbooks relieve a teacher in the matter of spending a large amount of time in lesson planning, ineffective teaching may result if the teacher is not careful. On the other hand, a physics test intelligently employed enables both teacher and students to save a great deal of time and energy. If the average teacher endeavored to get together such a large body of facts, properly outlined and organized, the task would be tremendous.

Every experienced physics teacher has set up standards for his classroom and laboratory teaching which are quite definite. In casting about for a text he will inquire as to whether or not the contemplated book meets these established standards.

There is certainly no single, accepted organization of physics teaching. Actually there are an indefinite number of organizations possible, depending largely upon the viewpoint and purpose of the curriculum maker. The effective physics teacher will verify the suitability of definite topics to be given in the course. Many studies on this point offer advice that is experimentally sound. The text selector then must be alert to determine if the physics book chosen meets this need.

One must guard against the text which presents the subject matter in such a way that the mature and relatively finished product of the adult mind is represented, rather than a process which follows the natural movement of the pupil's mind. Instead of representing the starting point for reflective thinking, such texts are the result of such thinking. Furthermore, instead of refining, testing and developing vague concepts in the realm of experience, finished products of the scientific method are presented. A sequence of items should be developed which will correspond as closely as possible with the order which the scientist follows when in search of the solution of his problem. In this way original thinking is encouraged.

Physics teachers should free themselves from adherence to the logical organization and learn to appreciate the psychological organization, using as a basis the world of the pupil.

Although the physics laboratory is the place for pupils to acquire their knowledge at first hand, this method must of necessity be slow and tedious. Therefore, only a small portion of the field of physics can be taught by subjecting the pupil to actual personal experiences. For this reason, a well-selected and intelligently used text must furnish the basis for the major portion of physics which it is thought the pupil should master. Whenever possible, the pupils should first be introduced to the topic in the laboratory or demonstration, whereupon the text should be used to follow the laboratory experiments. In this regard, a text with a good index will prove invaluable as a ready reference book. An intensive consideration of fewer topics rather than an extensive survey is generally believed to give the best results in physics teaching. Theoretical physics topics may be most wisely taught by being interspersed among facts which can be used as a foundation for the theory. It is believed to be pedagogically unsound to teach theories entirely segregated from other portions of the science.

Motivation in teaching is perhaps found in larger measure in educational films, excursions, trips and clubs, than in the text itself. Nevertheless, many motivating devices, such as colored illustrations, diagrams, graphs and half-tones serve as excellent means of motivation in modern physics textbooks. Problematic situations, set up in connection with these illustrations by cleverly worded titles, do much to motivate the subject matter. Many good modern physics texts supply self-testing exercises and other learning devices in the form of reference readings, biographies, and suggested projects and problems. In this manner individual differences may be cared for.

Many physics texts overemphasize factual material. The text should not only be a source of infor-

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Criteria of a High School Biology Text

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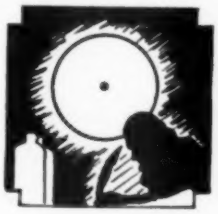

Some one has said that the choice of a biology text is a matter for the individual teacher inasmuch as there appears to be considerable variance in the philosophy of education in biology. What seemingly meets the ideals of one as desirable, may not conform to the opinions of others. It is true that there are texts which embody a philosophy ranging from those with an emphasis on natural history to those emphasizing structure and classification. Others emphasize functional aspects and the physiological phases of the subject. Ideas as to the real purpose of the subject are almost chaotic.

Educators have been influenced by the "do something different" craze to the extent that confusion has resulted. Criticism that biological education does not produce results in the life of the individual has caused the addition of many new phases, some rather dilute.

Out of the admittedly confused thought of the past there have evolved a few fundamental ideas in the light of which we may scrutinize today's text.

The modern text should have a content which bears a definite relationship to everyday life and behavior. A treatment of biological principles is needed, as opposed to a mass of unrelated scientific facts. Young people must correctly interpret press and radio advertising if they are to be properly fitted for efficient everyday living. Biological knowledge should enable them to differentiate between the legitimate practitioner and the quack and the charlatan. Through it they should be able to distinguish and appreciate the truth. The knowledge whereby they may do this must come in part from the text they use.

While the principles involved in the subject are numerous, certain ones are of outstanding significance, being definitely related to everyday life in the world about us. To enumerate a few does not imply that there may not be others equally important. In my opinion those which a modern text should emphasize, since they have a definite practical bearing on life, are understandings concerned with: (1) the use of food and oxygen by living things; (2) the units or cells of which living organisms are composed; (3) the dependence of one form of life on another; (4) the relationship of plants and animals to others of their kind; (5) the nature of disease and its spread; (6) factors having an important bearing on health; (7) reproduction of plants and animals; (8) influences of heredity, environment and individual effort, and the possibilities of plant and animal improvement; (9) mental and social hygiene not objectionable to mixed groups and adapted to the age level; and (10) economic relationships of plants and animals to man. Facts, while very necessary, should be subordinated to ideas and to principles. A good text will not only develop and point out effectively the importance of these principles, but it will teach the pupil to make practical application of them in his daily living.

Inculcation of the scientific method is sufficiently important that it must receive attention. A good text will allow a student to draw conclusions from presented facts. The ability to do this results in the formation of desirable habits. Scientific attitudes should be encouraged. Training in the ability to think is something which many texts do not encourage because the author draws all the conclusions.

Of foremost importance is the question of interest. An interesting presentation arouses student interest and attention, and makes the problem vital and purposeful. Many texts may be attractive to the teacher or to the specialist, but some of them overlook the fact that it is the point of view of the pupil which needs attention. Simplicity of statement, as well as appropriateness of subject matter, is essential. Biological terms must not be too difficult. Beginning students find difficulty when there is an abrupt transition of ideas, or too concise treatment.

Biology should be presented as a unified whole, not as separate entities such as botany, zoology and physiology. The unit presentation, with each unit a major principle subdivided into problems all of which have a bearing on that unit, seems to me to be a very teachable organization of a text, and therefore desirable. The problems, when skilfully handled, are frequently challenging to the student.

The question of flexibility of texts for groups of varying ability is worthy of thought. Until recently mass education was accepted, and texts were organized on that basis. Present emphasis seems to be directed toward the individual. Such being the case, provision should be made for the superior and for the inferior as well as for the average pupil. It would seem desirable to accomplish this by graded exercises, problems, and experiments in connection with each principle, thus providing for individual differences.

Laboratory exercises should be correlated with the text. Whether laboratory exercises are in the text or in a separate workbook or manual is not important,

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Choosing Chemistry Textbooks in Pittsburgh

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In the city of Pittsburgh, new adoptions in chemistry, as well as in all other courses, involve a considerable expenditure of the taxpayers' money. Consequently, they are made only after very careful study.

The book selected must be the best available, and one not likely to be outdated in a short period of time. It must meet specific needs not covered by the books in use. The need may result from a change in the course of study, from a change in the point of emphasis resulting from a change in general policy which may modify the objectives to be achieved; or, as is often the case, it may be due to the fact that the book in use is not sufficiently up to date to be satisfactory.

When it has been decided that a new adoption is to be made, the various textbook publishers are so advised. In order to be fair to all publishers and not under obligation to any particular one, it is the policy of the administration not to ask for complimentary copies as is so often done. Sufficient copies of each text available are purchased to make it possible for a representative group to make a comparative study and reach an unbiased conclusion concerning the relative merits of each. With this in mind, a committee is selected to make the study and evaluate each book.

The evaluation is made in the following manner:

In the first place, criteria are set up covering such points as objectives, subject matter, organization of subject matter, pupil and teacher aids, language, and general makeup of the book. In order that the committee's judgment concerning these may be as objective as possible, each one is carefully analyzed and broken up into a number of items, and then evaluated in accordance with its relative importance to the whole setup. For example, subject matter, as one of the most important of the criteria, would receive a higher rating than objectives, which may be of less value but, nevertheless, important. The detailing and evaluation of the various criteria will be somewhat influenced by existing circumstances as well as by the personnel of the committee. Subject matter details, for instance, will be determined by the course of study which has been previously set up. Since each text will be checked by each committee member against the salient ideas to be covered in the course, it is evident that a fairly objective composite value can be assigned with reference to subject matter.

Each criterion is thus detailed, individually checked, and values assigned in accordance with the original evaluation as set up. These individual values are then totaled. The total score arrived at in this way is used to determine the rank of each book, the one receiving the highest score being ranked first, and so on. The individual member's rankings are then brought together into one final composite rating, from which the committee's final rating of the books is made. With such care in making independent evaluations, there can be little doubt that the final rating is quite objective and free from individual bias.

Finally, this composite rating is turned over to a second committee consisting of an associate superintendent of schools, the director in charge of the department of curriculum study, and the director in charge of science. This committee reviews the report and makes the final recommendation to the board of education.

In this manner, it is believed that favoritism with respect to publishing companies and book agents has been eliminated, and the best text available, meeting the immediate needs of the classroom, has been chosen. ●

RADIO CLUB PRIZE

Visitors to the recent Duquesne University Science Conference were impressed by the excellence of the science project material that had been loaned for exhibition by numerous Catholic high schools throughout the country. One of the most extensive displays was the collection of pupil-made radios shown by the Radio Club of St. Philip and James High School, Phillipsburg, N. J., through the courtesy of Sister Mary Ruth, R. S. M., teacher of science.

Those who saw the display in Pittsburgh will be interested to know that eighteen of the radios which formed a part of the Pittsburgh exhibit were later entered in a competition at the American Institute Science and Engineering Fair, which was held, in March, at the Museum of Natural History in New York City. Two prizes were won: a third prize for the best group display, and a third prize for the best individual entry.

We congratulate both the members of the Radio Club and the teaching staff of the school on this splendid achievement. We are sure that this success will, as it should, stimulate them to further efforts.

Scientific Criminal Detection

• By J. Edgar Hoover, LL. B., LL. M., LL. D., *(George Washington University)*
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We take great pleasure in presenting this paper to our readers.

Chemistry, physics, biology, metallurgy and other branches of science are employed in the great number of scientific examinations which the Federal Bureau of Investigation of the United States Department of Justice makes each year for the purpose of detecting criminals. Sometimes science points out the guilty one after all other means have failed.

In this factual article Director Hoover tells of the work being done in the Technical Laboratory, the largest and most efficient criminological laboratory in the world. No particle of evidence is too insignificant for his experts to study. No expense is spared. No trouble is too great.

The Bureau of Investigation contributes to the public safety far more than most persons realize.

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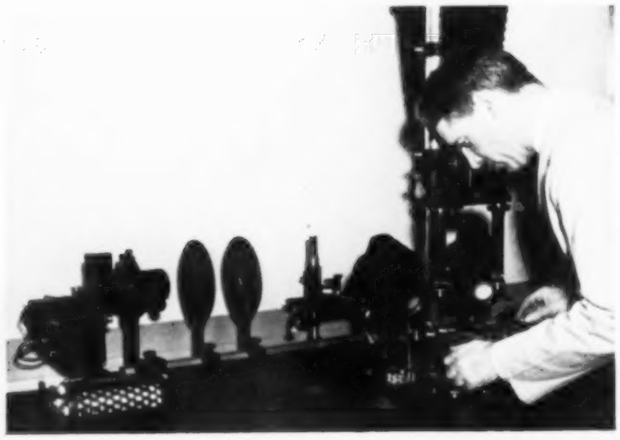
The examination of evidence found at the scene of a crime on a sound, scientific basis has become a necessity during recent years. Today, progressive law enforcement officials look upon the technical laboratory as an indispensable unit which must be relied upon in bringing about the conviction of modern criminals through impartial scientific laboratory study of various types of physical evidence obtained in criminal investigations. With the establishment of the Technical Laboratory of the Federal Bureau of Investigation, United States Department of Justice, at Washington, D. C., in the fall of 1932, the results obtained by means of scientific analysis of evidence in the laboratory have amply demonstrated the necessity of including examinations of this type in all possible fields of criminal investigations. Since 1932, the Bureau's Technical Laboratory has grown from a mere source of information file, maintained by one man, to its present size as the largest criminological laboratory in the world. Various types of scientific examinations of evidence are conducted daily by almost one hundred different experts throughout the Bureau, making the solutions of crimes, which a few short years ago would have been unending mysteries, a mere routine assignment.

To insure accuracy of examination and credibility of the experts conducting the various studies in the Technical Laboratory, it has been, of course, necessary to carefully select personnel unquestionably qualified for that type of work on the basis of extensive scientific educational background and practical experience prior to entry in this service. Each of the applicants for positions in the Technical Laboratory must, in addition to possessing high educational standards and practical experience, be specially trained in the crime laboratory along police lines in the various fields of scientific investigation to which he is suited. The modern criminological laboratory is confronted with a problem very dissimilar to the ordinary industrial laboratory in that in the latter instance examinations are generally restricted along definite types of work, whereas the organization serving a police agency must be equipped and prepared to handle every conceivable type of scientific examination.

Every branch of science eventually finds its way into the examinations being performed in the modern laboratory of police science. It would serve little purpose to list the various kinds of examinations performed in the Bureau's Technical Laboratory or to set out the many different types of scientific instruments needed in conducting these examinations. It is sufficient to say that we have available all types of apparatus applicable to the work performed, and have not hesitated to place at the examiner's disposal the scientific instrument, whether it be a spectrograph or a high-powered microscope, which would be necessary to assure the successful examination of a particular particle of evidence. The great expense involved in outfitting a technical laboratory such as ours, is of course compensated by the results obtained. Its success is based upon the

Experts collecting dust and debris from clothing for microscopic study, Technical Laborator[y] Federal Bureau of Investigation, United States Department of Justice.



An expert using the comparison microscope to compare a fatal bullet with one fired from a suspect's gun, at the Technical Laboratory of the Federal Bureau of Investigation U. S. Department of Justice.

qualifications and training of the examiners, in addition to their having for their use the type of high precision instruments necessary in arriving at exact conclusions.

All of the examiners in the Technical Laboratory are trained as photographers, and those who previously had extensive photographic experience are assigned to photographic examinations and experiments involving detailed knowledge of that science. The full-time staff of the Technical Laboratory is engaged in such work as document examinations, which includes any and all types of examinations of either written, printed or coded messages; the examination of firearms and kindred ballistic fields. Several experts are engaged in conducting chemical examinations, including toxicological work and the work covering the general field of chemical analysis. Continual examinations are made in the field of blood analysis where determinations are made whether or not a particular stain is human blood, and, if so, the actual grouping or typing of that stain is determined. The staff includes experts qualified in the field of moulage reproductions and in the science of examining glass fractures, and in the study and examination of bullet holes in glass and in other substances. Hair, rope, fiber and dust analyses are made, and in another section of the Technical Laboratory qualified experts are engaged in examinations pertaining to geology, metallurgy and soil analysis.

Radio technicians conduct constant experimentations in an effort to better adapt equipment of that nature to the exigencies of various types of cases falling within the investigative activity of law enforcement agencies. Qualified physicists in like manner utilize the Technical Laboratory as a workshop for their experiments with sound apparatus and various types of signaling devices which have proved of inestimable value to officers engaged in investigations at the scene of crime. Bomb analyses, lock examinations, cryptographic analyses, and electrical studies are also made in order to give the investigating officer on the scene of the crime definite answers to the clues which have been developed during the course of investigation.

The vast facilities of the Technical Laboratory of the FBI include innumerable reference files so classified and indexed that the experts can, within a short time, search new incoming articles of evidence against these files to determine whether or not the current case under investigation is connected with any previous cases which have come to the Bureau's attention. The reference files contain fraudulent checks used in swindling schemes, sample writings in extortion or threatening letter cases, a file containing false and fictitious automobile titles, bills of sale and kindred instruments used in passing automobile ownership. Almost two thousand samples of different types and sizes of ammunition are used for reference purposes as well as a reference file on all known types of guns. A blueprint file on known tire tread designs, a complete footwear file, typewriter standards, samples of ropes and cords, watermark descriptions and different kinds of newspapers supplement the reference files at the disposal of the experts of the laboratory.

The manner in which each type of scientific examination is conducted could not possibly be described in one short article. It is clear, however, that no particle of evidence, regardless of its size or seeming unimportance, can be considered too small or too insignificant for technical study in the Bureau's Laboratory. In a recent case the deep-seeing eye of the microscope enabled an expert of the Technical Laboratory to determine that the wisp of hair found clinging to the door hinge of a suspected hit-and-run automobile was identical with comparison specimens of hair removed from the head of the child found lying unconscious with a fractured skull at the edge of the highway. In another instance, the printed fabric found wrapped around a murdered victim's neck was found to be identical with similar fabric found at the home of a suspect. In a third instance, the stain appearing upon an ax recovered at the home of a suspect which he claimed was only rust was found to be blood of human origin and resulted from a murderous attack in which the ax was used on one of the suspect's neighbors.

In another case, the petrographer in the Technical Laboratory by adding polarizing elements to the microscope was able to examine the colored interference patterns produced by birefringent crystalline materials and thereby determine whether the soil removed from the shoes of a suspect was similar in mineral content and structure to soil taken from the area where a safe, which had been stolen from a local merchant, had been forced open and the contents stolen. Innumerable instances such as those cited have enabled the investigating officer, armed with the scientific findings of the laboratory expert, to proceed to the trial of the suspect and convict him in cases which a few short years ago would have been left unsolved, not due to a lack of evidence, but unsolved because existing evidence was not recognized as such by the investigating officers

A brief reference to typical cases received in the Technical Laboratory of the FBI patently shows the modern necessity of utilizing every conceivable scientific means available in the examination of evidence. A telephone cord and a pocketknife were submitted to the

Bureau's Technical Laboratory for examination, and the experts there were advised that the telephone cord apparently had been severed by a burglar in an effort to delay notification of the authorities of the crime, and that the pocketknife had been recovered in the possession of a suspect apprehended during investigation subsequent to the crime. In addition to the examination of other evidence sent to the Technical Laboratory at the same time, the experts were requested to ascertain whether the suspected pocketknife had, in fact, been used to cut the telephone cord.

Under the microscope there were observed minute bronze colored stains on the cutting edge of the knife blade. These stains were far too small to permit their ready removal and identification by routine chemical analytical methods. It was, therefore, necessary to conduct a spectrographic examination of the cutting edge of the knife blade which revealed the presence thereon of the two chemical elements copper and tin, which elements were found by a similar spectrographic examination of the back edge of the knife blade to be elements not a part of the blade material itself. Inasmuch as a spectrographic analysis of the telephone cord indicated that copper and tin were the principal constituents of the line which had been cut, this information was immediately given to the investigating officers for their further investigation of the case. The examiner from the Bureau's Technical Laboratory testified as to his findings at the trial of this case, as a result of which, together with other evidence gathered by the investigating officers, the suspect was found guilty of burglary and sentenced to a penitentiary for a long term.

The full value of scientific examination of evidence in the solution of criminal cases comes to light when circumstances and facts are considered such as those which presented themselves in the case of the State of Colorado *versus* Everett B. Hughes. Investigation in that case of the fatal killing of Mrs. Hughes by her husband at Pueblo, Colorado, on January 3, 1938, led to the subsequent arrest of Everett B. Hughes and his confession of having participated in the shooting. He strongly maintained, however, that he had acted in self-defense under fear of death to himself. Hughes presented the following version of the crime—a version which was difficult to controvert because there were no eyewitnesses to the shooting:

His wife, the victim, hated him and had threatened to leave him in favor of another man. On the night of the killing she had become particularly belligerent and had seized a revolver and had started advancing toward him, giving every indication that she intended to kill him then and there. He had no chance to escape, and, being in fear of immediate death, he had seized a .22 rifle standing nearby and had fired a shot which passed through her head and caused her immediate death. He was then extremely frightened and took the victim's body to a spot in the country nearby where he buried it in a shallow grave.

Hughes claimed that the burial was not occasioned by a feeling of guilt but was merely the natural consequences of his fright. The Sheriff's Office at Pueblo, believed that this was a cleverly planned and deliberate murder, and intensive investigation into the circumstances surrounding it was launched.

It was found that Hughes had, a few days before the murder, secured from the victim a number of sheets of paper bearing her signature on the bottom. He had secured this writing under pretext, advising his wife that they were to be used to write verses on in connection with festivities in the Hughes' home on New Year's Eve. Hughes had written a few verses on these slips of paper, but he had kept some and had written typewritten letters to his son and daughter over the victim's signature, which stated that the victim hated him and was soon to leave him. He had even typed a letter to himself which contained a similar message. These circumstances indicated that Hughes had been planning the murder of his wife for some time.

Examination at the scene of the crime indicated to the investigating officers that the murder had been brutally and quickly executed. Although Hughes maintained that his wife had been shot while moving toward him in one part of the house, a chair, in another part of the house, contained stains that resembled blood. It appeared that Hughes had shot his wife while she was sitting in this chair quite unaware, but without eyewitnesses it was difficult to establish this fact.

The section of the chair containing stains and the .22 caliber rifle belonging to Hughes were transmitted to the Technical Laboratory of the Federal Bureau of Investigation for extensive analyses and tests. Findings of the examiners in report form were furnished to the Sheriff's Office at Pueblo, Colorado.

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Technician viewing a suspect package through the use of X-ray equipment. Technical laboratory, Federal Bureau of Investigation, United States Department of Justice.

Nature and Functions of Microbial Life in the Soil

• S. C. Vandecaveye, Ph. D., *(Iowa State College)*
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The activity and functions of microbial life in the soil are varied and numerous, interesting and important.

Teachers of science will be glad to have authoritative information concerning the plant and animal micropopulation of the soil. Some forms are useful; some are predatory. Some help plants grow; some harm them. Here is a discussion of the common forms of soil microorganisms, how they act, and what they accomplish.

In this brief article Dr. Vandecaveye has successfully condensed a wealth of information selected from his own very broad field. He regrets that he had to sacrifice much important material in the interest of brevity. We are sure, however, that our readers will be pleased to have the special information he offers here.

In a practical sense the soil may be, and commonly is, thought of as a medium for plant growth. It is much more than that.

Genetically it is a natural body composed of disintegrated rocks mixed with partially decomposed organic matter and possessing specific, inherent characteristics acquired largely through the influence of climate and vegetation. As a center of life it is a complex body inhabited by an invisible micropopulation more diverse in character and participating in a greater variety of activities than the visible inhabitants of the earth. Any description of the nature and functions of this micropopulation, therefore, should give consideration to the soil as a medium for plant growth and also to the soil as a natural body. Such consideration has been attempted in this article.

The great majority of the species belonging to the soil micropopulation depend upon plant and animal residues as sources of food and energy in addition to needing such essential environmental factors as proper aeration, suitable temperature, and favorable moisture conditions. A soil possessing certain physical properties, a definite chemical composition, and a certain set of environmental conditions will also possess a well defined micropopulation. Any changes in the physical and chemical properties of the soil will be accompanied by quantitative and, frequently, also qualitative changes in the soil micropopulation, which belongs in uneven proportions to the animal and plant kingdoms, the latter including the large majority in kinds and numbers.

The microscopic animal world in the soil is represented predominantly by protozoa, nematodes, and rotifers, but not all species are microscopic in size. Some of the microscopic forms, however, are predatory, and others cause plant diseases or are otherwise injurious to plants. Although the predatory forms are known to destroy soil bacteria, there is very little evidence that their influence upon the microbiological processes in the soil in general is injurious. The protozoa, which probably make up the largest numbers in the soil microscopic animal world, have been studied most extensively also. They are most numerous in heavily manured soils, such as greenhouse soils, and, therefore, the importance of their functions and activity is greatest in those soils. Despite the fact that much has been learned regarding the distribution and functions of the soil microscopic animal forms in general, and of the protozoa in particular, present knowledge of their economic importance is still so limited that broad generalizations are impossible.

The microscopic plant world in the soil is represented by the algae, the fungi, and the bacteria, named in the order of their increasing importance of numbers and activities.

The algae are the only soil microbes which obtain their energy photosynthetically. Like the higher forms of plant life they contain chlorophyll and are capable of synthesizing organic matter from inorganic substances. The algae are universally distributed on and near the surface of the soil. They prefer nitrates as a source of nitrogen, and certain species appear to be capable of fixing measurable quantities of atmospheric nitrogen. They also exert a solvent action upon insoluble calcareous materials. Since algae synthesize organic matter, it is possible that they may accumulate soil organic matter. The fact that algae populate the soil in considerable numbers, and can store large quantities of energy in addition to manifesting the foregoing properties all point to their importance in the soil, although many of their functions are not sufficiently well known to generalize concerning the role they may play in soil processes.

The fungi may be subdivided into three groups: yeasts and yeast-like fungi, molds and other true fungi, and actinomyces. The importance of yeasts and yeast-like fungi in soil processes is not well known, but that of the other two groups is better understood and, therefore, considered more significant.

The genera of true fungi found most commonly in the soil both as to numbers of species and frequency of occurrence are: Zygorhynchus, Penicillium, Trichoderma, Fusarium, Mucor, Aspergillus, and Rhizopus. They are free living heterotrophic microbes which de-

pend upon the decomposition of organic substances for energy. Their existence in the soil is closely connected with the decomposition of organic matter, and consequently with the formation of humus. They occur abundantly in soils rich in organic matter and acid in reaction. In view of the fact that fungi exist both in the form of vegetative mycelium and as reproductive spores, their exact numbers are difficult to ascertain, but their relative abundance can be estimated by plating on suitable culture media. The numbers thus obtained range from 10,000 to 1,000,000 per gram of soil, depending upon soil type and food supply.

Two important functions of fungi in soil processes are rapid decomposition of complex organic substances, and assimilation of soluble, inorganic, nitrogen compounds and minerals. The addition of farm manures, green manures, and other plant residues to the soil greatly stimulates fungus growth. The fungi assimilate as much as 30 to 50 per cent of the carbon and also relatively large quantities of soluble nitrogen for the synthesis of cell substance, and because of this assimilation the role of fungi in the growth of higher plants may be both beneficial and injurious, depending upon conditions. This may be illustrated by the "fairy ring" formation in lawns. When the spores of certain fungi germinate in the soil small circular areas are formed, and the grass, which is first stimulated by an increased supply of available nitrogen resulting from organic matter decomposition by the fungi, is later killed by insufficient food and moisture in the area of dense mycelium. The grass again develops luxuriantly when the mycelium decomposes and releases an abundant supply of available nitrogen. Regardless of any direct effect on plant growth, the natural consequence of the activity and vigorous decomposition of organic matter by fungi is the formation of humus and its effect on soil properties.

The actinomyces, or ray fungi, are a group of organisms whose systematic position has not been defined satisfactorily. Both physiologically and morphologically the actinomyces are differentiated from bacteria and fungi. They are more sensitive to acids than the bacteria and particularly the fungi. Unlike the bacteria which form various gases from carbohydrates the actinomyces produce no gas other than CO_2. They behave like fungi in this respect. Morphologically, actinomyces colonies are hardly distinguishable from bacterial colonies at the early stages of growth, but they are characterized later by the formation of a unicellular mycelium composed of hyphae showing true branching like those of the fungi. Thus, actinomyces are found to partake of the nature of both bacteria and fungi, and are to be classed tentatively as intermediate forms.

A large number of species of actinomyces has been isolated from the soil, and in some soils these microbes represent 40 to 60 per cent of the colonies developing on agar plates. The numbers of actinomyces may range from 100,000 to 20,000,000 per gram of soil. All species take an active part in the decomposition of organic matter, both nitrogenous and non-nitrogenous. The actinomyces appear to be better able to attack the less readily decomposable organic substances than are the bacteria or fungi. In contrast to the fungi the quantity of mycelium produced by actinomyces is small, and proportionally small amounts of nitrogen are assimilated. Consequently, the decomposition of highly carbonaceous organic matter by actinomyces has a smaller depressing effect upon ammonia accumulation than decomposition of these substances by bacteria or fungi. Claims have been made that actinomyces are capable of fixing atmospheric nitrogen but such claims cannot be accepted as positive. Important plant diseases such as potato scab, sugar beet scab, and mangel beet scab are caused by actinomyces. In soil processes the actinomyces play an important role in the formation of humus. Since they appear to be among the few soil microbes capable of attacking humus substances, they take an important place also in humus decomposition.

The dominant forms in the soil micropopulation consist of bacteria. Their number is so great and their activity so varied as to defy more than a tentative classification. Two large groups are recognized: (1) the autotrophic bacteria; and (2) the heterotrophic bacteria. The autotrophic bacteria can thrive on purely inorganic substances and obtain their carbon from the carbon dioxide of the atmosphere. The heterotrophic bacteria require for their nutrition substances which have been built up by other organisms and, therefore, derive both their energy and carbon from organic substances.

The autotrophic bacteria in the soil are concerned with oxidation processes and are specific in their requirements and activities. They are represented by smaller numbers and fewer species than are the heterotrophic bacteria, but they include forms which are indispensable in certain soil processes. Specific groups of autotrophic bacteria oxidize simple nitrogen compounds, iron compounds, sulfur compounds, hydrogen, and methane. The nitrogen and sulfur oxidizing groups play important roles in the process of liberating plant nutrients. Simple nitrogen compounds are nitrified first from ammonia to nitrites by one group of nitrifying bacteria, and second from nitrites to nitrates by an entirely different group of nitrifying bacteria. The sulfur compounds in the soil are oxidized to the sulfate form chiefly by one genus, Thiobacillus. Both nitrification and sulfur oxidation are important soil processes since plants absorb most of their nitrogen in the form of nitrates and their sulfur in the form of sulfates. All soils not extremely acid in reaction contain both groups of nitrifying bacteria, and all soils appear to be well populated with sulfur oxidizing bacteria.

The heterotrophic bacteria make up the majority of the bacterial population in the soil. In numbers determined by plate counts they may range from less than 1,000,000 to more than 50,000,000 per gram of soil. On the basis of nitrogen utilization, they can be subdivided into two groups. The first group is composed of bacteria capable of fixing atmospheric nitrogen in the presence of carbohydrates as a source of energy, and is represented by the symbiotic and non-symbiotic nitrogen fixers. The second group is composed of

bacteria which require for their metabolism soil nitrogen in organic or inorganic form.

From the standpoint of soil humus and nitrogen economy and of plant growth in general, the symbiotic nitrogen fixing bacteria are the more important forms of the two in the first group of heterotrophic bacteria. They are represented by the genus Rhizobium, commonly known as legume nodule bacteria. Through unremitting research over a long period of years, the physiology of Rhizobium has become better known than that of any other genus of soil microbes with the result that within reasonable limits the activity of the genus can be controlled to serve practical ends. By proper selection the "virulence", that is, the ability of the organism to form nodules and benefit the host plant, of particular strains of various species of Rhizobium has been built up to such a degree of efficiency that legumes grown on nitrogen deficient soils and properly inoculated with homologous cultures of these strains utilize as much as 350 pounds of atmospheric nitrogen per acre annually. Unfortunately, the story of the economic importance of Rhizobium is not complete without mentioning the susceptibility of the organism to the attack of a bacteriophage which causes lysis of the bacterial cell and consequent reduction or even arrest of symbiotic nitrogen fixation. The writer has observed cases in which the yield of alfalfa was reduced 50 per cent as a direct result of bacteriophage infection. Adequate control of the activity of Rhizobium requires not only the selection of virulent strains but of virulent strains that are bacteriophage resistant.

The non-symbiotic nitrogen fixing bacteria in the soil are represented chiefly by the Clostridia and Azotobacter. The former are anaerobic and for that reason are of secondary importance in cultivated soils. The Azotobacter is aerobic and of universal occurrence in the soil, although it is seldom found in abundance in soils having an acidity greater than *p*H 6.0. Azotobacter can utilize a number of hexoses, pentoses, alcohols, and organic acids as sources of carbon and energy, but in spite of this adaptability it fixes probably not more than 10 to 40 pounds of atmospheric nitrogen per acre annually, under average soil management practices. The potential nitrogen fixing power of Azotobacter is much greater than that, however, and intense study of the physiology and activity control of this genus offers a fruitful field of research.

The heterotrophic bacteria, which require combined nitrogen for their metabolism, comprise most of the forms of bacteria developing on the common culture plate. They consist of spore forming, non-spore forming, aerobic and anaerobic rods, cocci, and spirilli. Various groups are known to possess certain distinct characteristics with respect to activity and food requirements. All groups take part in numerous soil processes, especially those concerning the decomposition of organic matter and humus formation. It is in this connection that they, together with the fungi and actinomyces, play their most important role in the soil.

While the activity and functions of soil microbial life are varied and numerous, the transformation of organic matter with the production as well as destruction of humus, forms the major ultimate function of this micropopulation. Humus, the dark colored organic substance in the soil, is chiefly the product of microbial activity. When plant residues are added to the soil, an immediate preponderant increase in microbial activity results, manifested by both rapid multiplication of organisms and profuse CO_2 production. Usually bacterial development is stimulated first, but this is followed closely by a similar increase in fungal growth. Maximum numbers of both types of organisms are reached within 10 to 20 days when the major part of the readily available substances, such as sugars, starches, and water soluble proteins is utilized. The actinomyces, though stimulated from the beginning, attain maximum numbers only after the bacterial and fungal growth begins to subside, indicating that the former are better able to attack the less available organic substances, such as celluloses, fats, crude proteins and, possibly, lignins.

An interesting feature as shown by recent studies by the writer and his collaborators is that the dominance of any of the aforementioned groups of organisms and the total number of microbes in the soil are not determined by the total food supply as represented by the humus content of the soil, but primarily by the type of humus and corresponding soil properties. The dominant group in the microflora of a forest soil, for example, consisted of fungi, whereas the dominant groups in a grassland soil consisted of bacteria and actinomyces. Under identical temperature and moisture conditions the total number of microbes in the grassland soil with a humus content of 4.4 per cent was approximately five times as large as that in the forest soil with a humus content of 8.1 per cent.

Many of the characteristic physical and chemical soil properties which serve in differentiating soil types are imparted by the humus and by the organic matter decomposition products. In the beginning stages of soil development the character of the micropopulation is influenced very definitely by temperature and by the chemical composition of the plant residues serving as microbial food, but in later stages of soil development it is also reflected by the type of humus and organic matter decomposition products formed. Thus, while the chief role of the soil micropopulation is the transformation of organic matter with the resultant production of humus, the degree of its activity and the dominance of various groups of organisms partaking in the activity is very definitely influenced, one might say ultimately controlled, by temperature and type of organic residues returned to the soil. Eventually this influence is manifested by the formation of certain definite physical and chemical soil properties which affect the character of the soil not only as a natural body, as developed under native vegetation, but also as a medium for plant growth as produced by soil management practices under farming. ●

The Microscope and Science

• **By Thomas Vincent Frank**
CATHOLIC HIGH SCHOOL, ALTOONA, PA.

Members of the faculty of Duquesne University selected this essay for the gold medal award in the science essay contest for students in Catholic high schools conducted in connection with the University's annual Science Conference. A silver cup, for one year's possession, was awarded to Mr. Frank's school.

This essay was written under the supervision of Sister Mary Virginia, S.C.

Only one prize is presented personally to entrants in the contest, but this year the essays submitted by the six contestants whose names and schools are listed in another place on this page were deemed worthy of honorable mention.

Anyone who has had the good fortune to enjoy a trip through some foreign land, no matter how brief it may have been, cannot help but marvel at the wondrous and strangely unfamiliar sights that he encounters. The customs, habits and native mannerisms of each country appear separately as strange little worlds in themselves. Such distinctive peculiarities can be comprehensively and accurately described only through actual experience. The ocean steamer acts as an instrument whereby one is able to delve into these delightful educational wonders. As a result the traveler can pass on his experiences to the less fortunate about him.

In a similar way scientists in their travels to the microscopic universe employ the facilities of one of the world's most valuable instruments—the microscope. They fully realize its inestimable value. Without this unique but comparatively small method of transportation, our scientific representatives could but dream of a journey into that mysterious world of microbes and other minute objects. Most certainly, they would not have been able to describe the many things we know today concerning microscopic phenomena without the assistance of this ever-important instrument.

Anyone who has, at some time or other, peered into the long, thin barrel of a microscope can realize only in a partial degree the magnitude of discovery entailed with the creation of this wonder. By employing it, the almost inconceivable harmony of our invisible neighbors can be plainly perceived and definitely studied. It seems incredible that such an assembly of mirrors and lenses should constitute one of the greatest discoveries of all time. The invention and perfection of the microscope eventually prompted revolutions in practically every known branch of science. New industries and new hobbies rose to prominence.

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THOMAS VINCENT FRANK

An outstanding student, president of the senior class, member of the school band, winner of prizes in two other important essay contests. The eldest of six brothers. Wants to study medicine.

HONORABLE MENTIONS

The following entrants received honorable mentions of equal merit in the National Science Essay Contest. Names are listed alphabetically according to states.

Lela L. O'Neil, Holy Trinity High School, Washington, D. C. Supervised by Sister Mary Aloysius, R.S.M.

Bettie Orr, St. Gertrude's Academy, Cottonwood, Idaho. Supervised by Sister Mary Alfreda, O.S.B.

Laura J. Albert. McDonnell Memorial High School, Brooklyn, N. Y. Supervised by Sister Mary Cherubim Rita, O.P.

Francis Sieloff, Central Catholic High School, Toledo, Ohio. Supervised by Sister Marie Therese.

Mariagnes Verosky, Divine Providence Academy, Pittsburgh. Supervised by Sister Mary De la Salle, D.P.

Edward C. McChrystal, Judge Memorial High School, Salt Lake City, Utah. Supervised by Sister Mary Scholastica, C.S.C.

Some Aspects of Blood as a Physico-Chemical System

• By Julius Sendroy, Jr., Ph. D. *(Columbia University)*
PROFESSOR OF CHEMISTRY AND CHAIRMAN, DEPARTMENT OF EXPERIMENTAL MEDICINE, LOYOLA UNIVERSITY SCHOOL OF MEDICINE, AND MERCY HOSPITAL, CHICAGO, ILLINOIS.

We believe that this article may awaken new interests.

Dr. Sendroy's discussion is a brief but comprehensive treatment of an out-of-the-ordinary topic, presented in such a simple and clear manner that our readers should have little difficulty in following it. The accompanying diagram is important. We have seen no better one.

Teachers of every science will find in this paper new and useful information. It will bear re-reading and study.

In the theoretical and practical applications of classical physical chemistry to the study of blood, it is well to bear in mind that we are dealing with a fluid of unique characteristics and possessing unique functions. There is no better example of this specialized function of blood, from the physiologist's point of view, than that revealed by studies of the characteristic properties of its constituents, which enable blood to transport gases between the external atmosphere and the various tissues. For our purposes, we may regard the blood itself most simply as a suspension of about 35 to 40 per cent by volume, of red corpuscles in plasma. The red blood cells are biconcave discs, containing hemoglobin (the red coloring matter of the blood), lipoproteins, salts, and water. The plasma, a yellow fluid, is composed of proteins, phospholipins, salts, and water. If the blood is allowed to clot, in a change whereby serum fibrinogen is converted to fibrin, which is insoluble and removed, the resultant exuding fluid is known as serum. In this discussion, no distinction will be made between plasma and serum.

Practically, the important physiological gases are carbon dioxide, (CO_2), and oxygen, (O_2), although nitrogen, (N_2), is also carried by the blood. At times, carbon monoxide (CO), usurping the place, but not the functions, of oxygen, in the blood, is a decidedly important gas to consider. Oxygen is taken in by the lungs and carried in the blood stream to the tissues, where it is released for physiological oxidations, while at the same time, CO_2, the product of combustion, is removed and carried to the lungs, where the excess is exhaled. In this way, gas transport plays a vital role not only in the processes of external and internal respiration, but also in the maintenance of body neutrality.

CO_2, O_2, and CO are found, and transported mostly in bound or combined form in the blood. CO_2 exists mainly as bicarbonate, $BHCO_3$ (where B is an alkali, sodium (Na) in the plasma, and potassium (K) in the cells), with a small portion present as carbamate, mainly in the cells in which it is attached to hemoglobin, HbNH.COOK (where Hb denotes the hemoglobin molecule, an amino group (NH_2) of which has combined directly with CO_2). The oxygen (and CO) forms a compound wherein it is loosely attached to the hemoglobin molecule, so that association and dissociation occur reversibly with ease:

$$(1) \quad Hb + O_2 \rightleftarrows HbO_2$$

However, these gases, together with N_2, are also present in blood in uncombined form, simply physically dissolved in plasma and cells. Although the portions of CO_2 and O_2 present in this latter form at any one time are quantitatively small, nevertheless, they are physiologically highly important, as it is in the physically dissolved state that the gases enter and leave the blood and tissues. (*Roughly* approximated, CO_2 in blood is transported 87 per cent in the form of bicarbonate, 8 per cent as carbamate, and 5 per cent as carbonic acid.)

With the aid of Figure 1, a simplified version of the processes of the normal exchange of gases between lungs and the atmosphere may easily be followed. In using the dynamic diagram indicative of the various interrelationships involved, for the sake of simplicity we shall observe what takes place during the course of a single respiration as the blood is converted from the venous to the arterial state. Blood is shown as an isolated portion of fluid, with a single red blood cell surrounded by plasma. So effectively are some of its contents confined within the red cell while at the same time some plasma constituents are kept from entering, that the cell surface may be regarded as being very much like a physical, semi-permeable membrane.

At the beginning of inspiration, O_2 from the atmosphere, where it is present at a partial pressure of about 150 mm. of mercury (20.92 per cent), enters the lungs, mixes with the alveolar air (neglecting the dead-space air which is functionally inactive, and of the same composition at the end of inspiration as is the outside air) and is thereby reduced to a pressure of about 100-110 mm. of mercury. The O_2 then passes into the pulmonary alveoli of the lung capillaries, and into the circulating blood (here more properly, first into the plasma) by a process of simple diffusion. The venous blood, a portion of which now comes within range of our observation (Figure 1) at this precise moment, is at an O_2 tension of about 35 mm., having previously deposited a large part of its oxygen in the tissues. By the diffusion of oxygen from the alveoli there is now a restoration of the lost O_2, but because

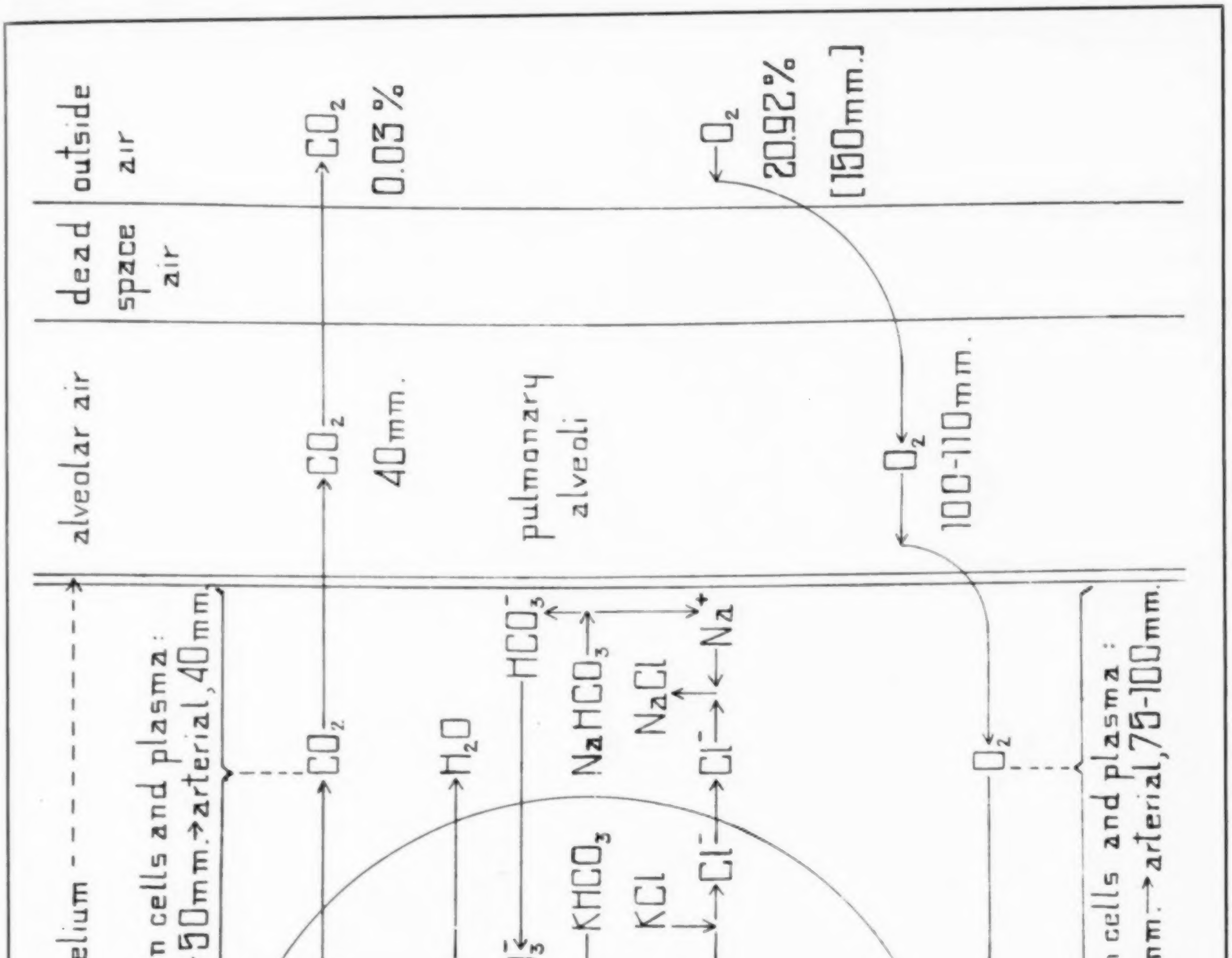

Fig. 1. Some aspects of blood as a physico-chemical system.

of the relative slowness of the diffusion (the rate of which for O_2 is about one-twentieth to one-thirtieth that for CO_2) there results a pressure gradiant such that the arterial plasma is constantly at a lower tension or partial pressure of O_2 (about 75-100 mm.), than that of the alveolar lung air (100-110 mm.). Diffusion of oxygen continues, and the gas passes through the cell wall from the plasma, in a rapid equalization process whereby the O_2 tension of the red blood corpuscle is likewise increased from 35 mm. to 75-100 mm.

In the plasma, the oxygen exists only in the simply dissolved state. In the cell, however, most of the dissolved O_2, as it diffuses in, is immediately combined with the hemoglobin anion (Hb^-) resulting from the dissociation of the venous, reduced hemoglobin, HHb. The oxyhemoglobin into which the reduced hemoglobin has now been converted, acts as a stronger acid, with an increased dissociation of an "oxylabile" hydrogen ion (H^+), with the net result shown by the equation:

(2) $HHb + O_2 \rightarrow H^+ + HbO_2^-$

At the same time, the bicarbonate compound in the cell dissociates:

(3) $KHCO_3 \rightarrow K^+ + HCO_3^-$

(In the cells, salts occur mainly with potassium as cation, whereas in the plasma, sodium is the predominant base.) The K^+ ion unites with the hemoglobin, which in the oxygenated state possesses an increased base-binding power, to form potassium hemoglobinate:

(4) $HbO_2^- + K^+ \rightarrow KHbO_2$

Simultaneously, carbonic acid, H_2CO_3, is formed by the union of H^+ ion and HCO_3^- ion, which cannot exist as ions in the presence of each other, in the increased concentrations arising from the dissociations indicated by Equations (2) and (3).

At this point, the physico-chemical conditions within and outside the cell are favorable for the release of free, uncombined CO_2. However, the liberation from the blood of amounts of free CO_2 sufficient to satisfy physiological requirements must be accomplished during the time it takes a red cell to traverse the lung capillary. The time of such passage is of about 1 second's duration, ordinarily far too short to permit, by a simple, physical process, the rapid unloading of CO_2 which actually does take place from the system. Fortunately, however, there is present in the cell, but not in the plasma, the enzyme carbonic anhydrase, which readily catalyzes either dehydration of H_2CO_3 with release of CO_2, or uptake of the gas by hydration. In the present case, the former process takes place. The complete equation for the reactions giving rise to free CO_2 from bicarbonate is

(5) $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$

The CO_2 gas, which is at a tension of 45-50 mm. in the venous blood entering the lung, readily diffuses out of both cells and plasma, so that both, in the arterial state, are very nearly in equilibrium with the alveolar air, at a CO_2 tension of about 40 mm.

The discharge of CO_2 from the blood is facilitated in other ways. When reduced hemoglobin is oxygenated, the carbamate salt is dissociated:

(6) $HbNH.COOK \rightarrow K^+ + HbNH.COO^-$

With further dissociation, the net total effect is expressed by the equation:

(7) $KHbCO_2 \rightarrow K^+ + Hb^- + CO_2$

Thus, the dissociation of the carbamate, which binds alkali as does bicarbonate, renders available more base for union with oxyhemoglobin, and at the same time releases labile CO_2. (The plasma proteins also form carbamate compounds the role of which in CO_2 transport is very slight.)

In the liberation of free CO_2 from the blood, another mechanism comes into play, namely, that involved in the approximation of, or tendency toward equilibrium between the electrolytes of the plasma and those of the red cells. In such a system as that shown in Figure 1, where there is separation by a semi-permeable membrane through which sodium ion, potassium ion, and the protein anions are non-diffusible, equilibrium is approached when reactions take place in the direction satisfying the following theoretical requirements for physico-chemical balance: (1), that on both sides, in cells and in plasma, the negative ions be quantitatively balanced by the positive ions; (2), that the distribution of the ions be in accord with the Gibbs-Donnan Law as expressed by the equation

(8) $$\frac{[A^+]_i}{[A^+]_o} = \frac{[B^+]_i}{[B^+]_o} = \frac{[C^-]_o}{[C^-]_i} = \frac{[D^-]_o}{[D^-]_i}$$

for cations (A^+, B^+, etc.) and anions (C^-, D^-, etc.) on both sides (i and o) of the membrane; and (3), that the two sides be in osmotic equilibrium. Accordingly, loss of bicarbonate from the cell as free CO_2 is furthered by the passage from the plasma into the cell of additional bicarbonate ions. This also serves to offset the loss of CO_2 from the cells as HCO_3^-, and from the plasma as free CO_2, and tends to compensate for the resulting slightly increased alkalinity of the plasma. However, migration of HCO_3^- ions into the cell can take place only by a simultaneous shift of an equal number of chloride (Cl^-) ions in the opposite direction, from the cells into the plasma, and approximately to an extent whereby the Gibbs-Donnan equilibrium is maintained:

(9) $$\frac{[HCO_3^-]_c}{[HCO_3^-]_p} \uparrow = \frac{f\,[Cl^-]_c}{[Cl^-]_p} \downarrow$$

Thus, as HCO_3^- ion is lost from the cells as CO_2, the ratio $[HCO_3^-]_c : [HCO_3^-]_p$ becomes less than the ratio $[Cl^-]_c : [Cl^-]_p$. Balance is restored to an approximate equality of ratios, by a migration of ions in opposite directions. In shifting from cells to plasma, the Cl^- ions leave behind K^+ ions available for other anions (oxyhemoglobin) and find awaiting them an equivalent number of Na^+ ions from bicarbonate dissociation.

Experimentally, the two anionic ratios above are

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Science as an Adventure

• By W. L. Eikenberry, Sc. D. *(Mt. Morris College)*
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Modern youth craves adventure as eagerly as did those soldiers of fortune of older days who explored the far corners of the earth. Since there are now but few unknown lands, the spirit of adventure must be satisfied in other ways. In seeking new outlets we should not overlook the appeal of investigations in the field of science.

Dr. Eikenberry's discussion of the problem is both interesting and practical.

This paper is a portion of an address delivered by Professor Eikenberry at the recent Duquesne University Conference for Teachers of Science.

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Man is ever a venturesome animal. In the days of his infancy, when he can first creep on the floor, he must needs investigate every forbidden corner in the house, pull down all the books and papers, climb upon every high object. A little older, he is not satisfied until he has explored the garden paths or lost himself in the woodlot across the way. Grown to manhood, the same urge for adventure sends him to the far corners of the earth to stake his life against savage animals, wild men, tropical fevers, or arctic rigors, if only he may adventure where few or none have tried before.

One generation of youths went to sea and sailed those marvelous clipper ships on voyages the like of which the world has not seen since. Another generation dreamed of killing buffalo and fighting Indians, and did in fact explore and subdue our great West. The present generation has taken to the air, quite in the spirit of the captains of the clipper ships, and the youth of today look with shining eyes upon the ships of the sky. Adventure, each generation will find.

It may be that Americans are a particularly venturesome people. Certain it is that our forefathers were those who were bold enough to leave home and country to try their skill and hardihood in a new and wild country. It was the spirit of adventure as much as anything else that sent the thin line of pioneers from the Allegheny Mountains to the Pacific coast in less than a century. Many an American family traces its history in a series of westward movements, always on the frontier, for three or four generations; and in this hard school their youth found adventure.

The frontier is gone. The onward flow of population has covered the country. The buffalo are in parks and zoological gardens; the red men are seeing the Wild West in the cinema, driving in automobiles or living on oil royalties. One must resort to a government reservation to find a bit of wilderness. There is little left to explore; but there are other opportunities for adventure. In all ages there have been those who adventured into a world of new ideas. The unknown savage who first tamed fire and reduced it from a scourge to a servant, who brought it into his cave and bade it warm him and cook his food, was a great adventurer. The primitive artizan who chipped the first crude stone tool, the hunter who first domesticated an animal, or he who brought plants into cultivation, each of them was a great explorer who opened to mankind a heritage greater than continents and oceans.

Scientific investigators are the lineal descendants of the Stone Age men who learned how to bring fire, stone, plants and animals under control. Men who in earlier periods might have been exploring new and unknown parts of the earth's surface are now exploring new continents in the physical and biological sciences, thus bringing the phenomena of nature under control. The present is a period of scientific discovery as the sixteenth century was a time of geographical exploration. In two centuries following Columbus, people came to know more about the geography of the earth than in all previous human history; in the past two centuries more has been learned about the nature of the earth and about the nature of natural phenomena than had been learned in all human history. This is the epoch of the scientific investigator.

Those who have won this new knowledge have dared, have risked, and have suffered as greatly as did any explorer in tropic jungle or arctic snows. In order that we might know how to use the new knowledge, they have sacrificed health and even life itself in working with x-rays. They have died of yellow fever, of typhus, and of other diseases in order that means of prevention or cure might be known. They have labored in the laboratory, on mountain tops, in the air, beneath the sea, by day and by night, in order that new knowledge might be won.

The fruit of knowledge is power. Knowledge of the laws of nature has given men power to accomplish tasks far beyond even the dreams of earlier generations. Thus, the earlier explorers found here a continent and showed us both its outline and the character of its interior, but there were few who could foresee a great future for it. By most people it was looked upon as a source of gold or other forms of easy wealth; there were few that cared to make their homes here. The great prairies of the interior offered no gold and were considered to be of minor value. Possibly this estimate was true, when men farmed with the tools of the Romans and depended upon oxen for transport. However, just as the tide of settlement finally filtered through the forests and out upon the prairies, the application of the new scientific knowledge supplied the settlers with the steel plow to turn over the soil, the

reaper with which to harvest the crop, and the steamboat and railway with which to transport the harvest to market. Almost immediately the prairies became the breadbasket of the world and their bounty overflowed to all the earth. Thus have man's discoveries given him power to control the material world to his own advantage.

The bodies of men have not greatly changed since the Stone Age. The Cave Men were not greatly different from ourselves. In sight, in hearing, in bodily strength, and possibly in mental keenness we do not surpass them. But, because during the intervening ages we have learned to devise mechanical supplements to our senses, we can see that which they could never see, we can hear what they never could hear, and we even perform tasks for which their strength was absurdly inadequate. The telescope, microscope, radio, steam engine, automobile, airplane, and a host of other devices have extended our own limited senses and powers. Such have been some of the great adventures of the human race as it has ever pressed against new and old frontiers.

The boys and girls who are in your classes are no less adventuresome than those of earlier generations. They, too, are looking for life's thrills, and they are going to find adventure somewhere. Are we ready to enable them to find in the new frontier of science some of the opportunities which appeared to be lost in the passing of the old frontier? If we do this we shall save many of them from the fatal adventures that lead in the ways of degradation and crime. We may even have the great satisfaction of seeing some of our own pupils in the ranks of the scientific investigators who are pushing back the boundaries of darkness.

The question that we must all face is, how are we teachers of science to make sure that at least a considerable proportion of our pupils shall find in scientific studies a real and satisfying adventure? In more pedagogical language, what methods shall we use?

A partial reply is to say that the very subject matter of science constitutes a new world. A look through a telescope or a microscope is a real adventure, opening vast and entrancing vistas. Likewise, most of the phenomena of physics, chemistry and biology are new to high school pupils. Such pupils are yet in the stage of getting acquainted with their environment. A large number of them will be greatly interested merely in securing the answer to the question "What is it?" This is good, but it is not enough.

Most of us have learned long ago that most children are hero-worshipers. They like to read the story of adventurous lives. We have responded by regaling them very largely with the lives of military heroes, or with the military phases of the lives of those whose activities were only partly military. Thus, one who listens to the radio addresses on Washington's Birthday could scarcely conclude therefrom that he was not only "first in war," but also "first in peace." We have neglected almost wholly the heroes of science, whose constructive activities are more dramatic, more self-sacrificing, and more valuable. We science teachers have scarcely used the inspirational material which is ready to our hands in the history and biography of science. What marvelous stories we could make if we set ourselves to it, out of the struggles, failures and successes of such men as Pasteur, Koch, Lister, Steinmetz, Father Nieuwland, Einstein, or a hundred others.

The essence of the scientific method is the solution of problems—the investigation of the unknown. Youth likes to solve problems, too. Our pupils ought to have opportunities to solve real problems that are of interest to them. The writer well recalls the best lesson on this point that ever came to him, for the lesson was taught by a ninth grade science class. They were studying winged seeds in accordance with the demands of the syllabus and the textbook. "Lay the fruit on its side and draw, labeling the wing, the seed, etc." Actually they were surreptitiously dropping the seeds to see them spin. The discipline was not above criticism. In after-school ponderings on the reasons for the disorder, it occurred to me that in fact the class, not the teacher, was right. They were trying to find out something, and I was trying to prevent them from doing so. The next class was asked to start study by dropping the seeds and watching them descend, under controlled conditions. The result was a happy, interested class which was solving a problem and therefore learning something. There are problems in plenty; it is for us to find them and use them.

My last point as to method is that problems must be solved in the presence of the materials and phenomena involved. The pupils must in most cases handle the objects and perform the experiments, as they almost universally wish to do. You can call it laboratory work, child activity, individual instruction, supervised study, or by any other name. I care not, so long as the pupil is doing things himself and not merely watching someone else. I am well aware that there has been a school of thought which has asserted that a child can learn even better by watching than by doing, but the case is far from proven. The dictum of the great Agassiz was "study nature, not books." Some of our friends seem to have made it read "study books, not nature." A more conservative course is to study both nature and books.

To the present generation of science teachers it is given to lead adventurous youth, deprived of the outlet for its energies that served its predecessors, to find a real satisfaction and adventure in exploring the fields of science. In so far as we succeed, we shall have the satisfaction of having given to them a constructive vocation or avocation, of saving at least some of them from destructive pursuits, and of having guided at least a few into the ways of discovery and investigation by which the limits of our ignorance are pushed farther back. ●

Problems in Teaching Physics

• By Brother Hugh Martin, F.S.C.
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Brother Hugh Martin is an experienced teacher who has his own ideas about how physics should be taught. They are good ideas. He expresses his thoughts clearly and candidly.

You will be interested in what he has to say about mathematics and physics, about making study too easy for the pupil, about objectives, problems, workbooks, teaching devices and many other things.

This paper was presented recently before the Chicago Catholic Science Teachers Association.

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In metaphysics they say that the end comes first, meaning thereby that though the end is the last to be attained, yet it must be first in the intention of him who acts. Now in discussing problems which arise in the physics class we can also affirm that the end comes first, for in order to know what is a problem and what not, we must first know what end we are trying to achieve. Education might be characterized as a harmonious development of the faculties in order that the individual might better reach his end. If such a definition holds, and it seems to me to cover the case pretty well, then we must see how the subject of physics promotes this harmonious development of man.

Physics, in my opinion, contributes to the education of man in three definite ways: (1) by its informational content; (2) by its disciplinary character; and finally (3) by its so-called scientific method.

By informational content is understood that body of wonderful facts about the physical universe, and that deeper insight into every-day phenomena, which is imparted so aptly by the science of physics and which can produce such a profound impression on the human mind. This, we think, is the first and grandest contribution of physics to education. Equipped with scientific knowledge, the individual begins to come out into the broad daylight and understand what he sees taking place on all sides. No longer does he harbor the superstitions and prejudices of ignorance, but he adopts a matter-of-fact attitude towards truth.

But there is also the disciplinary character of physics. The discipline of this science is its ability to present a challenge to the higher faculties of the mind, its capacity to afford us a mental "workout", if we might borrow a term from athletics, and this discipline arises from the mathematical nature of physics. The rigorous mathematical laws of technical physics offer perhaps the best opportunity for the boy to see how the algebra and geometry he has studied enter into the constitution of the real world about him. One sometimes hears pedagogues decry the emphasis put on mathematics in this science on the ground that the pupil is studying the underlying principles and is not taking a course in applied mathematics. They make mathematics a rock of scandal. Such criticism, it seems, is unfortunate. Were you to take away mathematics you would take away the physics together with it, so closely are the two associated. Moreover this idea of diluting the curriculum by eliminating difficulties is detrimental to the interests of the brighter boy and harmful to the development of the intellect. Too much of modern education is passive and to little of it is active. To confine education to the passive reception of facts makes way for mental laziness. It takes some virile mathematics to give the lad a chance to set his logical powers in action.

Finally we come to the scientific method. Not the least benefit of physics is to aid the individual in acquiring a scientific frame of mind. Although it is true that most boys will never be called upon to make an accurate scientific measurement after they leave the physics laboratory—they never again measure the voltage of their electric circuits, or the mechanical advantage of a lever—yet they should carry with them a scientific outlook which would lead them to check their logical conclusions with the facts, to verify their reasoning by experiment, and to keep an open mind towards the truth. If they will not be *producers* in science, they should at least become intelligent *consumers* in science. With all the fads and quack advertisements of today it is no small advantage to have an intelligent, scientific outlook on such things.

With these three benefits to be attained from physics, the information, the discipline, and the scientific method, the teacher has his work cut out for him. A number of difficulties crop up both for student and for teacher. After all, I suppose both have about the same difficulties, for what is a difficulty for the student is *ipso facto* a difficulty for the teacher. In the first place, it is hard to adjust the course to give due prominence to each of these objectives. I suppose the average boy signing up for the physics course does so with the idea that he is going to learn something new and mysterious. So it is important to keep the class interested by offering an abundant and varied diet of interesting facts and demonstrations. I find it useful, whenever possible, to produce some piece of apparatus or machinery to illustrate what is being said during the lecture on the subject. A tin shears, a crow bar, a drill, anything to let them see and handle will serve. If one can succeed in keeping up the wonder and interest of the class, he is a long way towards his goal.

Then there is the mathematical side of physics to attend to. Doubtless there is a good fraction of the class who wouldn't mind if you never mentioned mathematics, but also there are always a number who are naturally gifted along mathematical lines, or who in-

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tend to pursue science in college—possibly with the idea of taking engineering. This last group must be considered, and with this in mind it is well to give a solid mathematical framework to the course. When it can be arranged, I believe it is a distinct advantage to have the physics teacher teach the same class advanced algebra as well. Only in this way can the two subjects be made to help each other to the fullest extent. But we must take heed not to stress mathematics unduly lest many be estranged from the course. Hence, in assigning problems to the class I often try to include some mathematical ones and some non-mathematical, in order that everybody will be able to work some of them. To challenge the particularly bright ones, a difficult problem can be assigned as optional, with the reward of a bonus towards the week's mark. That this is an incentive was shown by one lad who wrote next to his problem that we had corrected in class, "Brother, don't forget this one when making out the week's mark."

I find it useful to require that they write the formula on which the problem is based before starting to solve it. This makes for logical thinking. And when substituting in the formula they are required to keep the units after the numbers substituted and cancel: pounds, feet, etc., just as they would the numbers themselves. In this way it is easy to arrive at the correct units in the answer, and furthermore it serves to eliminate the errors that arise from mixing English and metric units or mixing different denominations of the same unit, such as centimeters and meters. Thus if the problem were to find the pressure at the bottom of a water tank one hundred feet high, the formula would be:

$$P = h \times d$$

substituting: $P = 100 \text{ ft.} \times 62.4 \text{ lbs./ft.}^3$

canceling ft. units and multiplying: $P = 6240 \text{ lbs./ft.}^2$

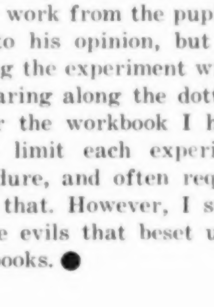
Problems that have some bearing on the boys' daily experiences are excellent, for they connect up the subject matter with practical affairs. In this way the mind gets a concrete grasp on the principles.

In connection with the mathematical side of physics it may be useful to introduce a little side activity. I refer to the operation of the slide rule. It usually happens that a number of boys have the ambition to become engineers and somehow or other they picture an engineer as a rough and ready fellow in leather boots carrying a slide rule. They jump at the chance of learning how to multiply and divide and perform other operations on the slide rule. We introduced lessons on the slide rule at St. George High School this year which were attended by about twenty boys. They obtained inexpensive rules for a dollar or so, and were quite enthusiastic on the subject. A large Manheim demonstration rule, seven feet long, was procured which aided in teaching the whole class at a time. The slide rule is of use in solving problems and computing the results in experiments, and of course, is a useful acquisition to anybody's fund of information.

The scientific method, one of the big objectives of the study of physics, is to be taught through the work done in the laboratory. The emphasis on laboratory work and individual experiments is characteristic of scientific pedagogy in America. They tell us that far less stress is put on experiments in Europe. There is considerable discussion relative to the manner of conducting laboratory experiments. Should the experiment precede the study of the theory, or should the theory precede the experiment? This seems to be the bone of contention. It is true that in the original development of science, experiments are usually performed to bring to light the hidden truths of nature, and the argument is that if this is the scientific method, why not follow it in the laboratory.

On the other hand, as somebody said, it would take ten years to get the full benefit out of the experiment if we had to approach it in the same state of ignorance in which the law was first discovered. I am for the system of explaining clearly the theory and laws before going into the laboratory, and making the experiment consist in a verification and illustration of the principles already known. Much time can be wasted in the laboratory if the students are allowed to flounder about in the dark, so to speak. High school pupils ought to know just what they are required to do and the why and wherefore of the experiment, if they are to derive the full benefit. As it is, some act in the laboratory as if they were in a labyrinth, so befuddled are they by the maze of apparatus. Usually they are the ones who missed the explanation.

While we are talking about experiments, the subject of a laboratory manual comes to mind. Unfortunately a certain teacher has been plagued with a poor laboratory manual—a so-called physics workbook. If anybody is looking for advice, let me tell him to beware of workbooks. They certainly mean work—hard work for the teacher and poor work from the pupil. Of course everyone is entitled to his opinion, but I don't favor the system of limiting the experiment writeup to filling out a form sheet, tearing along the dotted line, and handing in. Moreover the workbook I have in mind is so contrived as to limit each experiment to a single method of procedure, and often requiring a new type of apparatus at that. However, I suppose we have to bear up with the evils that beset us—even with poor laboratory workbooks. ●



The National Association of Biology Teachers

• By P. K. Houdek, Secretary-Treasurer N.A.B.T.
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The Editor requested Mr. Houdek to prepare this article so that this new Association could be brought to the attention of all the biology teachers in Catholic high schools throughout the country. Every teacher in the field should consider joining it.

We have learned that a considerable number of the more progressive teachers in the Catholic schools have already become members. An officer of the Association reports that in a number of cases they have already given helpful suggestions. He states that the Association is glad to have them join because of the high standards that the teachers in Catholic schools maintain in their training and in their attitude toward their work.

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A national survey indicates that there are approximately twenty thousand teachers of biology and related sciences in the high schools of the United States. Prior to 1938 there were but six scattered organizations of biology teachers. Teachers in other sciences had long since perfected numerous organizations and in a number of cases had established national associations.

Research biologists and professors of biological sciences in many of our colleges and universities have long seen the need of strengthening the teaching of biology in the high schools. The recognition of this need was crystallized when the Union of American Biological Societies established a committee on the teaching of biology, under the leadership of Dr. Oscar Riddle of Carnegie Institute. After a survey of the field this committee was able to secure a grant from the Carnegie Foundation to promote the teaching of biology. The first work of this committee was the establishment of The National Association of Biology Teachers.

On July 1, 1939, fifteen biology teachers, representing 1500 biology teachers in thirty-five states, met in New York City, organized the National Association, elected officers, and established their journal, *The American Biology Teacher.*

The purpose of the national association is to organize biology teachers in secondary schools on a national basis, whenever possible, by forming local biology teacher associations, in order to:

a. Facilitate the dissemination of that biological knowledge which is most vitalizing and useful to the public in everyday life.

b. Encourage scientific thinking and the utilization of the scientific method through the teaching of biology in our schools.

c. Make available to high school teachers information concerning the selection, organization and presentation of biological materials; and to advance and strengthen the relationships of the subject to other sciences and to education as a whole.

d. Provide a national journal dedicated to the foregoing objectives.

The association is governed by an executive board composed of its officers, and the editor in chief and the managing editor of the journal. By constitutional provision, a majority of the executive board must be classroom teachers of biology below the college level. The officers are classroom teachers of biology; they are in touch with the problems that an association can help to solve.

The journal, *The American Biology Teacher,* contains fundamental articles, methods, devices, materials, projects, news, equipment, books, research, club suggestions, exchange service and other types of articles of practical value to biology teachers. The editorial staff includes many of the recognized national leaders in biology and education. Requests for sample copies should be addressed to the secretary-treasurer.

Local organizations of biology teachers are given all possible aid and cooperation by the national association. It is recognized that great value is to be derived from local meetings. Teachers are urged to form and support a local group wherever possible. Where sufficient interest is shown, the national officers will assist in the formation of local organizations. Interested teachers singly or in groups are urged to join the association and to communicate with the officers concerning organization plans.

The following local, state and regional organizations have already affiliated with the National Association:

Biology Teachers Club of Southwestern Pennsylvania
Chicago Biology Round Table
Detroit Biology Club
Greater Cleveland Biology Society
Illinois Biology Teachers Association
Kansas Association of Biology Teachers
Miami Valley Biological Society
New England Biological Association
Southern California Association of Biology Teachers
The New York Association of Biology Teachers
West Central Indiana Biological Society

Membership is open to anyone interested in the teaching or promotion of biological science. The dues of $1.00 per year, include a year's subscription (eight issues) to the official journal. Applications for membership should be sent to the Secretary-Treasurer.

Its considerable growth in membership since its organization is evidence of the welcome that this new association has received from biology teachers over the country. Averaging over one hundred new members each month, the membership now includes teachers in forty-four states, several Canadian provinces, and two foreign countries. ●

A Course in Nature Study

• **By David W. Rial, M. A.** *(Clark University)*
PITTSBURGH PUBLIC SCHOOL SYSTEM.

Nature study in Nature's own laboratory!

Nothing could be more appropriate.

Whatever materials are at hand can become good teaching devices if the scientific background of the teacher is broad enough.

This is a story of an unusually interesting out-of-doors summer course for teachers conducted by an experienced and enthusiastic instructor, Vice Principal of the Frick Training School for Teachers, Pittsburgh. It contains many suggestions concerning materials and procedures that should be helpful to teachers of science in secondary schools.

A friend once designated a course in nature study as an attempt to describe the Universe and give two examples. Facetious as such a remark may be, perhaps it is not too inept after all.

But just what should be included in such a course for a summer's work in this field?

The problem becomes increasingly difficult of solution in view of the fact that the many subjects which might be touched upon in such a series of studies are major courses in colleges and universities. However, during a summer session of Duquesne University, the author attempted a solution of the problem by following a *laissez faire* policy. The outline of the summer's work was planned as definitely as it might be, but sufficient flexibility was given it to permit individual or class interests to dominate the situation. A further stimulus to such a program was added when it was decided to give the course at Mt. Alvernia, the Mother House of the Sisters of St. Francis, located in a busy suburb of Pittsburgh.

The grounds surrounding the building are unique in many respects. Included within the boundaries of the premises is an area of about thirty acres. This comprises a rich, tillable hilltop suitable for vegetable and orchard farming, some grassy slopes, and a deep ravine covered with a dense vegetation of trees and vines, a suitable hiding place for certain types of animal and vegetable life.

The physiographic aspects of the locality are anything but monotonous. In geological circles the terrain of the Allegheny region at the forks of the Ohio is known as the dissected peneplain type. This affords the student near Mt. Alvernia a splendid opportunity to study some of the geological structure of the region.

The neatly kept campus portion of sloping meadowland presents ample opportunities to study permanent grasses, and a considerable variety of wild and cultivated flowers. There is also a large assortment of both hard and soft wood trees, mostly native wood, and a few of foreign origin whose habits were intriguing to study. In brief, here was a laboratory inexhaustible in resources, where we might listen to nature as she spoke her various languages.

The first hour of the morning was given over to lectures, reports or discussions of observations that had been made. Then, sometimes in groups, sometimes individually, the class left the classroom to study in the outdoor laboratory. Later, perhaps, specimens of plant and animal life were brought in for closer study with the microscope or dissecting instruments. Often the class could get no farther than the front steps, so demanding were the observations to be made in every direction. Standing quietly, one could note the song of the cardinal, the meadow lark, the field sparrow, the wood thrush, or away in the distance a bobolink. Attempt at imitation of bird calls serves a double purpose, a quicker identification and a desire for more intimate knowledge of their lives. Pursuing such a purpose, we studied the nesting habits of the wren, robin, English sparrow, and other birds that prefer nesting close to human habitation.

In the distance the old base levels of the Allegheny and Ohio River system could be observed with the even skyline so significant to the geologist.

Whether near or far, here were many inviting observations arousing one's curiosity and asking for solution. We would study both nature and books,—Books at our will or peril.—Nature as she wooed us, but in whatever direction she might lead.

Projects or interests galore presented themselves and called for investigation. Like Kilpatrick's idea of education, one idea grew into another, and as one progressively developed, another appeared and demanded study. But to illustrate:

A bird bath was needed for the center of a canna bed. A shallow place was hollowed out in a stiff clay near the greenhouse. The shape of the hollow was exactly the form desired for the underside of the bath. Many had never seen a concrete mixture made. What proportions of sand and gravel should be used? How would the thickness of the concave dish be determined? Should it be reinforced? Where would we get the sand? Could we use the loamy sand at the foot of the garden path, instead of sharp river sand? Where would we seek answers to such questions? Who makes a study of such problems?

To shape the concrete, wooden pins (matches) were driven into the mold for thickness determination, like engineers drive spads into an area for leveling. Since smoothing the concrete mix of sand and cement was too awkward for a trowel, the hand became the most convenient instrument for such a purpose. Into the

smoothed surface leaves of many trees, crazy patch like, were pressed. A few days later when our creation was removed from "the forms," the interior of the bath had written into it a simulated fossil story.

The isolation and quietness of the grounds seemed to be an invitation to many birds to make it their meeting place. Had we ever seen anything come into life? How many have? A neighbor farmer loaned a broody hen. At the end of the incubation period, many of the class for the first time saw baby chicks pick their way into an outside world.

A feeding station for temporary or permanent bird residents was set up. Suitability for observation as well as the requirements of the birds were given careful consideration and study. Near it, some bird houses, which we hoped the birds might see fit to use, were erected.

The soils of the ground were as varied as one might expect in any such region. Here were some stiff ferruginous clays, some rich garden soils, and some limey shales near a calcareous outcrop. Students collected some of the clay and dried it so that the coarse pebbly portion might be separated before using it for modeling clay. Some very presentable vases were molded from the product in addition to discussing the whys and wherefores regarding pottery making and related arts.

Soil was treated with suitable reagents to determine its acidity, phosphorus content, et cetera. Was such soil good for strawberries? We had already potted a hundred or more. The *p*H value of the soil offered a big question mark.

As mentioned above, a deep ravine afforded a fine opportunity to study the underpinning of the location. Here and there along the lower portions of the same, scraps of the Ames Limestone had been found. What a "find" to the geologist of western Pennsylvania. That fairly thin layer of limestone, wherever located in this portion of the state, is the point of departure for the identification of all other rocks.

Above it, at a distance of about three hundred feet, would be found the Pittsburgh coal, below it, at about the same distance may be found the Freeport vein. In a similar manner other rocks could quickly and definitely be determined. We were surely in the vicinity of the ledge. Imagine the pleasure to note that the main buildings of the institution actually rested upon this layer of rock. What luck!

Rock formations very naturally lead to inquiry as to earth origins, and that of our neighbors in the universe. The subjects of longitude and latitude therefore had a new interest to us. An approximate method of determining the latter was accordingly worked out.

As nearly as possible, the exact north-south direction was established. Even a small error in direction does not materially affect the problems upon which the class was working. In a field giving a clear view to the north, two pieces of two-by-four studding were driven into the ground along the established north-south line. Using a carpenter's level, a small board was fastened to the broad side of these stakes. Thus a horizon line was established, pointing in a northerly direction. In the evening when Polaris became visible, a second board was securely nailed to our horizon line board but pointed as one would aim a gun at the north star. Measuring the included angle between the two pieces of wood gave us a surprisingly close approximation to the latitude of Pittsburgh as determined at the Allegheny Observatory, a not distant neighbor to the Mother House. As is well known, the latitude of any place on the earth's surface is the altitude of the elevated pole.

On clear nights by means of a home made reflecting telescope, we made observations of the moon in several phases; an observation of Jupiter and its moons; also Saturn and Mars. The relative positions of the planets enabled us to pick out the Zodiac. Before the short term was over, many of the important constellations of the summer sky had been identified and became familiar objects to the class. Very naturally these experiences led us to carry out one of the most interesting projects of the whole course, the setting up of a sun-dial.

In this problem, a suitable level spot with a southern exposure was chosen. It was planned to set up a much larger sun-dial than is ordinarily conceived. A space above twelve feet in diameter was selected from the southernmost periphery of which a trench two feet deep, a foot wide, and two feet long was dug. A soil pipe was set in concrete in this trench pointing exactly at the north star. This angle previously determined was the same as the latitude of the school. A stick of timber, either a piece of two by four studding or a sapling, was inserted in the open end of a pipe to serve as our gnomon or stile. This, of course, made an angle with the horizontal corresponding to the latitude. Instead of calculating where the hour marks would fall around a symmetrical curve, the exact hour marks of the shadow, morning and afternoon, were located as the sun apparently moved across the sky. There was no end to the use that could be made of the space around such a sun-dial. The Sisters of St. Francis chose to make it a location where a continual round of flowers would bloom, beginning with the crocus and the daffodils of spring. But for the most part perennial wild flowers suitable for such a habitat were chosen. This latter study of suitable locality furnished an incentive for not a few ventures, not the least of which was an opportunity to try out some of the ideas in plant propagation.

The new synthetic hormone indolebutyric acid developed at the Boyce Thompson Institute was tried with stem cuttings. While the period of summer class was entirely too short to derive satisfactory data, nevertheless, rooting with such easily rooted material as grape and rose was speeded up. The small greenhouse was of special assistance to us in this case. A splendid young fruit orchard gave us a chance to try our hand at budding. Again, as in the case of the root cuttings, the time was too short to note the best results, but it gave us a good conception of the method used in such procedure.

The proof of the pudding is in the eating, if we

Continued on Page Fifty-four

Photograph by Robert Turriff Hance

NEW BOOKS

Soilless Growth of Plants

By CARLETON ELLIS and MILLER W. SWANEY, Reinhold Publishing Corporation, New York, 1939. 155 pp. $2.75.

This book presents for the first time, and by authorities, all necessary technical information for growing plants without soil but in properly balanced nutrient solutions. The methods are not new to botanists but have only recently been brought to public attention and to commercial use. The book is beautifully illustrated and gives the amateur and professional alike an adequate discussion of the necessities of agriculture, including descriptions of the recent studies of plant growth stimulants known as hormones.

Robert T. Hance

•

A Laboratory Introduction to Animal Ecology and Taxonomy

By ORLANDO PARK, W. C. ALLEE, V. E. SHELFORD, The University of Chicago Press, Chicago, Illinois. 1939. x + 272, $2.00

A growing appreciation of the need to know animals as they live in native habitats will find much needed direction in this new laboratory guide. Preceding the synoptic keys to animal orders are excellently clear and brief discussions of factors surrounding the lives of animals. For advanced students the rather long bibliography will be helpful. The glossary will aid in following the keys. The loose leaf construction of the book will permit the insertion of additional blank sheets or of new printed pages if desired.

Robert T. Hance.

•

The World and Man As Science Sees Them

Edited by FOREST RAY MOULTON, The University of Chicago Press, Chicago, Illinois. 1937. xix + 533. $3.00

Thirteen men who are known for their technical work as well as for understandable descriptions of their findings have collaborated in the production of a book setting forth the essentials of their respective fields of activity. The result is eleven good resumés of important scientific conclusions.

Astronomy, geology, physics, chemical processes, the nature and origin of life, the problem of life and reproduction in the plant kingdom, evolution and behavior of the invertebrates, vertebrates and physiological processes, microorganisms and their role in nature, man, are treated adequately and interestingly. Many as are the illustrations, in this age of pictures, even more could have been added to the advantage of the text. A happily brief but excellent bibliography suggests sources of more detailed information in each of the discussed subjects.

It seems to be but quibbling to question the unity of a book written by so many writers. The difficulties connected with such authorship are commented on in the Foreword. The decision to be made in an attempt to tie man up with his world (and between two covers) must almost necessarily lie between the complete authority of the writers and the desirable unity of the text. Where it shall be is, obviously, a matter of opinion, but the reviewer has never been convinced that such summaries give beginning students a satisfactory basic background on which to build. For use as a senior summation of a college training, as a means of yoking together the diciplines of departmentalized education,—that would be something to think about.

Robert T. Hance

•

Animals Without Backbones

By RALPH BUCHSBAUM, The University of Chicago Press, Chicago, Illinois. 1938. ix + 371. $3.75

The age of pictorial news through which we are now passing has happily touched the biological text and very much to its advantage. No body of specific zoological information available today is better illustrated than is "Animals Without Backbones—An introduction to the invertebrates."

No one need agree with the educational philosophy of the "Chicago Plan" to grant that it has stimulated new thought in the organization of texts. The drawings and photographs in the present book are both numerous and striking, calling attention once more to the many interesting books coming from the Press of the University of Chicago.

Dr. Buchsbaum has an unusual facility in penning brief legends to the illustrations that often include more understandable information than is available in many lines done in the accepted textbook style.

This book should be in all college and high school libraries for reference. Its use as a textbook would seem to be limited to the courses in invertebrate morphology that frequently follow the general course in zoology.

Robert T. Hance

•

Animal Life in Fresh Water

By H. MELLANBY and L. E. S. EASTMAN, Chemical Publishing Company of N. Y., Inc. New York. 1938. viii + 296. $3.50

In comparison to "Animals Without Backbones", this book by two English authors must be classed with the standard type of "morphological taxonomies" to which we have long been accustomed. The writing is well done and the illustrations are clear cut line drawings. This book should serve well as a guide to the study of invertebrates. There can be but little question that it will suffer by comparison with the much more brilliant format of the "Animals Without Backbones" which also has the possibly temporary advantages of newer methods.

Robert T. Hance

Personal and Community Health

• *By* C. E. TURNER, A.M., Sc.D., Dr.P.H. Fifth Edition. C. V. Mosby Company, St. Louis. 1939. 652 pp. $3.00.

A textbook of hygiene that passes through five editions in fourteen years does not require a detailed review. It has already demonstrated its worth. Teachers in colleges and universities throughout the country, institutions of all sizes and types, have found Dr. Turner's book useful enough to require it as a text in their classes.

It is deservedly popular.

The book deals with the broad field of personal and community health in an interesting manner. It is authoritative, up to date, and thorough. The author writes clearly and well. The illustrations are appropriate. An unusual feature is the use of "eye-toned" paper having a slight greenish tint.

This book will be a worth-while addition to any library. *H.C.M.*

Chemistry and its Wonders

• *By* OSCAR L. BRAUER, Professor of Chemistry and Physics, San Jose State College, San Jose, California. American Book Company, New York. 1938. vi + 760 pp. Illustrated. $2.00.

An examination of this book leads the reviewer to believe that the author must be a successful teacher. He knows how to make chemistry interesting, but he does not sugar-coat. The publishers have done their part in providing an unusually attractive format.

Dr. Brauer has taught both high school and college students. He knows chemistry. He knows the needs of pupils for whom high school chemistry will be a terminal course. His college teaching has shown him where the training of the college freshman is likely to be deficient. In writing his book he kept in mind the needs of both groups.

The basic material offered is well presented. It is amplified by a study of the applications of chemistry to health, agriculture, transportation, warfare, industry, and other fields. Questions are given on the special reading references as well as upon the material included in each chapter. The illustrations are not hackneyed. The drawings are excellent.

As is to be expected, teachers will differ with the author on at least a few points. For example, valence is taught as a tool in Chapter 5, but atomic structure is not studied until Chapter 21.

A laboratory book by the same author, entitled *Exploring the Wonders of Chemistry*, sells for $0.48.

H.C.M.

Exploring the World of Science

• *By* CHARLES H. LAKE, HENRY P. HARLEY, and LOUIS E. WELTON, Cleveland Public Schools. Silver Burdett Company; New York. 1939. ix + 710 pp. $1.80.

This is a new edition which brings up to date a successful textbook which first appeared in 1934. The many good points of the first edition have been retained and in some respects emphasized. Some of the sections have been revised considerably. New material has been added. Additional illustrations are included. The student of average ability, as well as the exceptionally able one, will find material to fit his ability and needs. The self-test at the end of each chapter is a helpful device.

The teacher who reviewed the first edition of this book in our December, 1935, number, found the book to be one of the best textbooks in its field. The evaluation still holds good. *H.C.M.*

Plant Growth Substances

• *By* HUGH NICOL, Harpender, England. Chemical Publishing Company of New York, Inc., New York. 1938. xii + 108 pp. Illustrated. $2.00.

Although this little book contains two chapters addressed directly to the layman, most of its contents will be considerably beyond the comprehension of the reader who does not have a knowledge of organic chemistry. The layman who desires to experiment with growth-promoting substances and who does not care too much about the how and why, will find here much practical information. He is taught how to use such materials as indoleacetic acid and phenylacetic acid to produce roots on plant stems in unusual positions, or even on leaves. He is told how to speed up the rooting of cuttings. He learns about plant hormones, the production of growth regulators from natural sources, and the structure, synthesis, analysis, and identification of compounds that have proved to be effective in promoting growth. A rather extensive bibliography is included in almost every chapter. *J.F.M.*

Third Digest of Investigations in the Teaching of Science

• *By* FRANCIS D. CURTIS, Ph.D., Professor of Secondary Education and the Teaching of Science, University of Michigan; P. Blakiston's Son & Co., Inc., Philadelphia. 1939. xvii + 419 pp. $3.50.

This book should be invaluable to administrators, supervisors, and researchers in education who need to be informed about the research investigations that have been made recently in the field of science education. It is the third book of a series of digests, the publication of which was begun in 1926. This volume covers studies that were published in the years 1931-36, inclusive.

The members of the National Association for Research in Science Teaching aided Dr. Curtis in selecting the most significant investigations of the period. Each is considered under the heads Problem, Method, Findings and Conclusions, and classified in the elementary, secondary, or college field. Seventy-three studies dealing with the teaching of science in secondary schools are reported. Some are concerned with the science field in general. Others relate directly to the individual high school sciences. A supplementary bibliography of miscellaneous investigations relating to the field is included. It lists thirty-eight additional studies. *H.C.M.*

The Chemical Formulary

• *Edited by* H. BENNETT; Chemical Publishing Company of New York, Inc., New York. 1939. 638 pp. $6.00.

This book contains thousands of proved working formulas—some new, some old—for making a great variety of preparations for use in the home or school or in industry, such as adhesives, polishes, lubricants, insecticides, beverages, varnishes, ceramics, cosmetics, medicinal preparations, flavors, inks and cleaners. Other types are represented.

The emphasis throughout is primarily on recipes and directions for compounding, but considerable descriptive matter is included, and pertinent data are supplied. The introductory chapter, which discusses fundamental procedures in a simple manner, should be helpful to unskilled workers.

This is a useful book. In it you will find work with which to keep busy that unusually competent pupil.

A Biology of Familiar Things

By GEORGE L. BUSH, ALLAN DICKIE, RONALD C. RUNKLE, The American Book Company, New York. 1939. 695. $1.92.

The title presents a very satisfactory abstract of the contents of this book. The biology of health, disease, beauty, clothing, food, pets, pests, conservation and even of the future are set forth in a manner to bring out the practical applications of the subject. The book is broad in scope and excellently illustrated. For those who prefer to teach through the familiar to the unknown, the reviewer has seen no more comprehensive guide.

Robert T. Hance

Science in Our Lives

By BENJAMIN C. GRUENBERG and SAMUEL P. UNZICKER, World Book Company, Yonkers, New York. 1938. xiv + 754. $1.76

"Science in Our Lives" is another book at high school level attempting to line up in a rather encyclopedic way the knowledge that science has learned of the ways of man in his world. This book could well serve a course in high school general science although its trend is strongly biological.

The length of this book, as with "A Biology of Familiar Things", is such as to raise the question of the desirability of such extensive expositions for students at high school levels. Would not briefer statements on each subject be better understood?

Robert T. Hance

Deserts

By GAYLE PICKWELL, WHITTLESEY HOUSE, McGraw-Hill Book Company, Inc., New York and London. 1939. xiv + 174. $3.50.

"Deserts" does the author, who is also his own photographer, very proud, and the publishers deserve sincere congratulations for the masterly reproduction of text and illustration that they have helped to accomplish.

The biological problems of the desert come to life in the reader's imagination through the well written text that is so successfully and beautifully illustrated with sixty-four full page cuts.

Robert T. Hance

Birds

By GAYLE PICKWELL, WHITTLESEY HOUSE, McGraw-Hill Book Company, New York and London. 1939. xvi + 252. $3.50.

"Birds", by the same author and photographer as "Deserts", presents to the amateur and professional students alike a knowledge of birds decorated with exquisite portraits of his subjects at home and abroad. With two such books from the camera and pen of the same biologist, those who raise the question of the "cultural values" of science will have much of the wind spilled from the sails of their argument.

Robert T. Hance

Science Problems. Books I and II.

By WILBUR L. BEAUCHAMP, J. C. MAYFIELD, JOE Y. WEST. Scott, Foresman and Co., New York. 1938, 1939. Book One, $1.28; Book Two, $1.48

These textbooks are written for use in the seventh and eighth grades in the Junior High School. A third book, not yet published, will complete the series.

These books are examples of fine textbook making. Successful cooperation between authors and publishers is evident. The modern make-up impresses at once, colorful binding, wise selection of type, good planning and arrangement of material, new and original illustrations done in the latest style.

The subject matter is well adapted to the needs and interests of the pupils for whom it is intended. It is written in simple and clear language, and from the child's point of view. These are books to attract the pupil as well as to impress the teacher.

The unit problem plan is employed. Principles are developed through simple student-performed experiments. An attempt is made to train the child to think logically. Many supplementary exercises and problems are included. Self tests, book lists, and other aids are provided. The "looking ahead" paragraphs and the material introducing each chapter should be especially helpful.

H. C. M.

General and Inorganic Chemistry

By FREDERICK G. IRWIN, B.S., and G. RAY SHERWOOD, Ph.D., Wayne University. P. Blakiston's Son & Co., Philadelphia. 1939. x + 582. $3.50

Despite some admirable qualities this college textbook of inorganic chemistry as a whole does not impress the reviewer. It suffers by comparison with other textbooks in the field. The material appears to be loosely knit. Certain fundamental concepts could have been developed more fully and more scientifically. The order of presentation of topics may be questioned. Many teachers might not consider the treatment of equations adequate. Much valuable space is devoted to very simple problems. Five chapters of organic chemistry are included, the authors assuming that organic chemistry is more interesting to the student than the material it necessarily displaced.

This book could well find a place on the reference shelves of a high school or college library.

J. F. M.

A Course in Nature Study

Continued from Page Fifty-one

may be allowed to mix our metaphors. In education, the permanency of the adaptations made is the acid test of one's work. So judged, the work of our class seemed to have a satisfactory carry over. Pupils of the Catholic elementary and high schools of the city have been returning with their teachers, former members of the class, to use the grounds of the school as a laboratory for nature study. Many times in contemplating these experiences, there has been borne in upon us the vastness of the opportunities at our door, even though we seem to be amazed to find them there.

Scientific Criminal Detection

Continued from Page Thirty-seven

Hughes was tried for murder at Pueblo on March 24, 1938. Two examiners from the Technical Laboratory of the Federal Bureau of Investigation were present to testify in behalf of the State of Colorado. As expected, Hughes' plea was self-defense.

The examiner from the Technical Laboratory of the Federal Bureau of Investigation who made the examination of the portion of the chair testified that the chair contained stains of blood. He was also able to say that these stains were caused by human blood. This testimony nullified the statement of Hughes that the victim had been shot in another part of the house while moving toward him. The testimony served to substantiate the charges of the State that the victim had been brutally murdered while sitting in this particular chair.

Other testimony was given by a firearms identification examiner from the Technical Laboratory of the Federal Bureau of Investigation to the effect that Hughes' gun had fired the shot which took the victim's life.

Further testimony given by this examiner was of vital importance in attacking Hughes' version of the crime. As a result of tests conducted in the Technical Laboratory of the Federal Bureau of Investigation, he was able to state that the gun used in the murder would make a powder residue pattern similar to that which surrounded the victim's fatal wound only when held within less than one-half inch from the object through which the bullet passed. This absolutely contradicted Hughes' statement and gave valuable support to the State's contention that Hughes had held the gun almost in contact with the victim's head while she was sitting in the chair, possibly sleeping, and had then pulled the trigger. Hughes' story of shooting his wife while she was advancing toward him and still at some distance was thus discredited.

Everett B. Hughes was convicted of murder in the first degree in State Court at Pueblo, Colorado, and was subsequently sentenced to life imprisonment.

It is doubtful if cases such as this could speedily be brought to their logical conclusion if it were not for the testimony given at court by qualified scientific criminologists who make it their business to show the criminal element that every available weapon of science is aligned along the battle front of crime to defeat the depredations of the lawless segment of our nation. ●

THE MICROSCOPE

Continued from Page Forty-one

For many centuries the world of little things remained undiscovered. In fact, the beginnings of bacteriology ran parallel with the development of the microscope. People knew nothing about the countless millions of invisible plants and animals that live in water, soil, air, foods and in our very bodies. Milk soured, fruit juices fermented, meats putrefied, vegetables decayed and diseases claimed many unfortunate victims, but people were totally ignorant of the real causes. They did not know that these conditions were brought about by millions of extremely tiny plants and animals, far too small to be seen by the naked eye. In 1683, Leeuwenhoek, a Dutch linen weaver, constructed a lens sufficiently powerful to enable him to see some of these minute objects. The importance of this remarkable discovery was not realized at that time. Nearly two centuries more passed before scientists began to study the world of little things in earnest. Each new discovery on their part was, therefore, a marked advance in the science of bacteriology.

Two very prominent phases of science, water sanitation and food analysis, have witnessed an extensive elaboration as a result of microscopic research. The suspended matter in drinking water is usually so small in quantity that it cannot be detected with the eye alone. If, however, a sample is allowed to stand and is then decanted, there is a trace of deposit left which can be easily examined under the microscope for chance harmful bacteria. A widely recognized means for identification of adulterants in many classes of foods is furnished by the microscope, which in most cases affords more actual information as to the purity of food than can be obtained by chemical analysis. In the case of cereal products, so commonly employed as adulterants, a microscopical examination is of paramount importance. One who is familiar with the appearance under the microscope of pure foods and starches and of various ground substances can with certainty identify very minute quantities of these materials with surprising ease. By chemical analysis an abnormal amount of crude fiber may show the presence of a woody impurity, but only the microscope will enable one to decide whether the substance consists of sawdust, chaff or ground nut shells. In such instances as these not only is a microscopic examination more accurate than a chemical analysis, but it is also a much quicker and safer guide.

The investigation of the form and optical properties of minerals when in microscopic form, has been much facilitated by the use of microscopes especially adapted

for this purpose. First arranged with reference to the special study of minerals as seen in thin sections of rocks, they have now been so developed as largely to take the place of the older optical instruments. They not only allow the determination of the optical properties of minerals with greater ease, but they are applicable to many cases where the crystals on hand are too small for other methods.

With the rapid increase made in comparatively recent times in the perfection of instruments at our disposal, and in our knowledge of the different appearance of body tissues and organs together with their secretions, the microscope has come to be an indispensable aid to medical diagnosis. Before the discovery of this practical and efficient instrument, medical men knew very little concerning the activity of microbes. Through the medium of this invention, they were able to solve many questions, principally relative to disease and physical destruction. In some instances, permanent remedies for many hitherto incurable afflictions were rapidly formulated.

The electronic microscope is, perhaps, the most modern convenience available to our present day scientists. This instrument is so constructed as to project on a circular viewing screen magnifications which frequently exceed the actual size of the object by one million times. It is believed that many significant new discoveries in the basic sciences of physics, chemistry and biology may result. Time alone will bring about a development of the unknown possibilities of this new invention.

In recent years, photomicrography has taken an important position among our list of hobbies. The photomicrograph serves as a simple means of keeping permanent records of unusual occurences met with in the course of routine examination. Besides offering a means for an enjoyable pastime, this instrument, which represents a combination of a microscope and camera, has also proved its usefulness as a means of evidence in court by showing as it does with faithful accuracy the presence of a contested adulterant.

Microscopic surveys have brought to light countless scientific wonders but, strange to say, the field of science has been but slightly developed as yet, and only roughly analyzed. Persevering patience and concentration on the part of our present and future scientists, who will be aided by more sensitive microscopes, will solve many scientific wonders yet to be revealed. ●

Some Aspects of Blood as a Physico-Chemical System

Continued from page forty-four

not exactly equal, one being a constant function, *f*, of the other. Nevertheless, the theory serves to describe the shift in ions which actually takes place across the cell membrane. The loss of electrolyte as Cl^- ions by the cells renders them osmotically weaker than the plasma. Osmotic equilibrium is restored by the passage of water from the cells to the plasma.

Upon respiratory expiration, the accumulated excess of free CO_2 is blown off by the lungs. The red cell, which we have been observing in its 1-second passage through the capillary, has already passed on together with other companions, in the stream of plasma surrounding them, as arterial blood. Thus, at any moment, the condition of the blood coursing through the pulmonary alveoli is such that it is in very near equilibrium with the CO_2 tension of the aleolar air (at 40 mm.) but is at a somewhat lower O_2 tension (10-25 mm. lower). From the reactions described, and indicated in Figure 1, it is apparent that the chain of events and the properties of the reacting substances are consistently such as to favor in every way the uptake by the blood of oxygen in the lungs, and the release of carbon dioxide. In the capillaries of the tissues, where the blood discharges its load of oxygen and picks up carbon dioxide, the directions of the reactions are exactly the reverse of those shown in Figure 1.

Although the foregoing analytical treatment necessitates a description of the mechanisms as a rapid sequence of events, in reality, all of the reactions occur simultaneously. Furthermore, in the interplay of reactions centering about the physiologically important chemical properties of hemoglobin for O_2 and CO_2 transport, the ready reversibility of the reactions, none of which runs through in any one direction to the complete quantitative exhaustion of any reacting substance, indicates that a series of equilibria are involved. The unique properties of the reacting substances may accordingly be studied by the application of mass law equations. Thus, the equation for the dissociation of carbonic acid,

$$(10) \quad \frac{[H^+] \times [HCO_3^-]}{[H_2CO_3]} = K'$$

indicating the state of the CO_2 in the circulatory fluid, is now generally used to describe accurately, the condition of the blood acid-base balance, which is a reliable index of the physiological neutrality of the organism as a whole. It is such applications of physical chemistry that have revealed the physiological fitness of blood for its tremendously important role in gas transport, in the maintenance of physiological neutrality, in responding rapidly to changes in the internal and external environment, and in general, in the maintenance of physiological stability.

In this paper, the treatment follows from an attempt to present the subject as simply and as briefly as pos-

sible. For more extensive developments and reviews of the physico-chemical phenomena discussed in this article, the reader is referred to the publications cited below. ●

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Criteria of a High School Biology Text

Continued from Page Thirty-three

provided that there is good correlation with the text.

Certain points of organization—for example, thought questions and review questions at the end of a unit—aid materially in making a teachable book. The vocabularies of new words with their pronunciations and definitions are an invaluable aid to the pupil. The use of tabular summaries is often a help in conveying information in a clarified form.

We learn with the eye with such ease and facility that every teacher will recognize the importance of good clear-cut illustrations and half-tones. Is your book well illustrated? This is a question of significance. If the answer is in the affirmative, it is quite likely that the book will attract more interest in the student.

With biology a dynamic and a growing science, a modern text should be up to date in scientific discovery or it will soon be outmoded in both facts and interest. Necessarily it should be correct, authoritative, and reliable in its information. Many textbooks have errors in them. Some texts are written by college professors who know little of the high school pupil's interests and limitations. I would not say that college teachers should not write books for high school use, but I do know that those written by high school teachers or by teachers who have had high school experience, frequently succeed in reaching the pupil better. There is less transition, and there is greater likelihood of the use of a common language. Finally, then, the author, his experience, the contacts that he has made, and the institutions with which he has been connected, are all worthy of note. But in the end these can hardly compare in importance with the influence

of his style, and the inspiration of his work upon our youthful students.

To inspire pupils so that they will want to learn more and more, even after school days are done, is indeed a rare attribute, and perhaps a more fitting challenge to the teacher than to the text. ●

What Physics Text Best Suits Your Course?

Continued from page thirty-two

mation but also a reliable and useful guide in applying the facts. Often, in a large body of facts, many appear to have little relationship to social usefulness. The application of physics in reflective thinking and problem solving should be stressed even if memorization of mere factual knowledge must be curtailed. In this way true understanding can be attained.

Wherever possible, the method of the scientist should be employed. A wrong deductive approach must not be used. This is, after all, not the way the mind attempts to solve a problem.

Perhaps the best way of arriving at an objective method of selecting a physics text is to use a score card in committee. This avoids the influence often exerted by high pressure sales methods, as well as personal bias. In making its evaluation, the committee should consider the subject matter, whether it is written in language easily understandable by the pupils, whether a proper physics vocabulary is introduced, whether individual differences are provided for, and whether the educational philosophy of the committee is provided for in the organization. Aside from these, the cost, style and format must also be considered. Furthermore, the selectors must inquire into the professional standing of the author, the reputation of the publisher, and the date of publication. It may often also be worth while to get the reactions of pupils to books under consideration.

Bearing these factors in mind, we may perhaps more effectively succeed in choosing a text which is adapted to the interests, abilities and needs of the pupils. ●

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